Vol. 16, No. 2 February, 1960

LUBRICATION ENGINEERING

DESIGN RESEARCH APPLICATION EDUCATION MAINTENANCE

This month:

BEARINGS

JOURNAL OF THE AMERICAN SOCIETY OF LUBRICATION ENGINEERS

Drums along the...

Long before the coming of the pale-faces, Indian drums throbbed along the Mohawk and other rivers on this continent.

In 1876, seventeen years after the discovery of oil at Titusville, Pennsylvania, The Brooks Oil Company began business by supplying kerosene to light the lamps of American homes and grease for the axles and wheels of Conestoga wagons. From this modest beginning, The Brooks Oil Company has developed into one of the major suppliers of lubricants for industry.

Today, The Brooks Oil Company ships thousands of drums of quality lubricants to industries located where the tribes of yesteryear had their villages.

Brooks Oil products have been used successfully for 83 years by industry throughout the United States, Canada and overseas.

Supplying SUPERIOR LUBRICANTS for todays highly specialized industry is our specialty.

LEADOLENE® KLINGFAST® BARCOTE® ROLLENE®

®Registered

A new 16 page brochure available on request

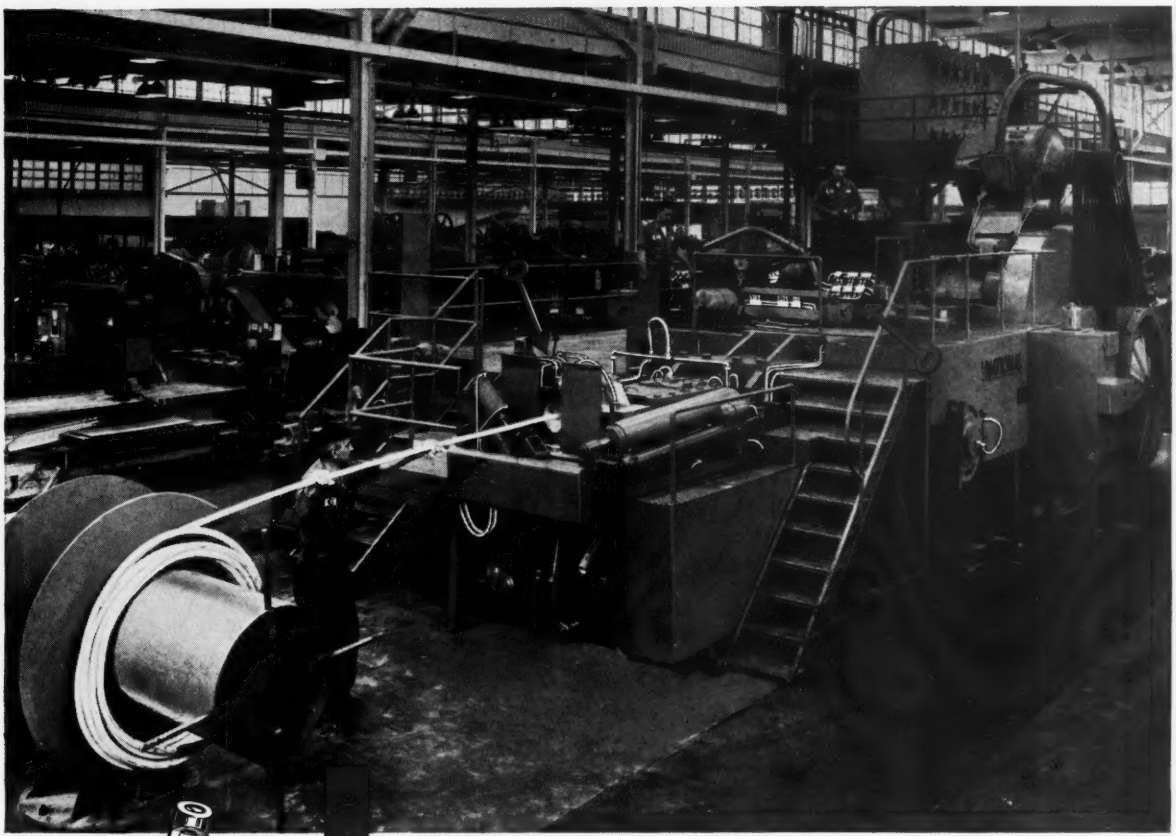
The Brooks Oil
International Company:
Exporters

OFFICES AND WAREHOUSES
IN PRINCIPAL CITIES
U.S.A. • CANADA

The BROOKS OIL Company

Established 1876

General offices and U.S. plant 3304 East 87th Street • Cleveland 27 Ohio
Canadian offices and plant 461 Cumberland Avenue • Hamilton Ontario



FARVAL—Studies in Centralized Lubrication No. 238

Farval automatically lubricates 138 bearings on world's largest Boltmaker

It's a 1¼-inch cold forger, designed and built by National Machinery Co. for the Cleveland Cap Screw Co., Cleveland, Ohio. This versatile machine automatically produces hex head cap screws. It draws steel rod to wire size, cuts it to proper length, extrudes the blank, heads, trims the head, points the end and then rolls on threads, all this at the rate of 38 complete screws per minute.

A Farval timeclock-controlled, motor-driven lubricating system guarantees against failure of the machine's 138 vital bearings, as well as supplying spray lubrication for the cold-forger's chain drive. If bearings should fail on such a high output machine—production costs skyrocket, profits take a nose-dive.

Write for revised Bulletin 26-S, which shows how Farval can extend both bearing and gear life on new machinery—as well as on older equipment now in use.

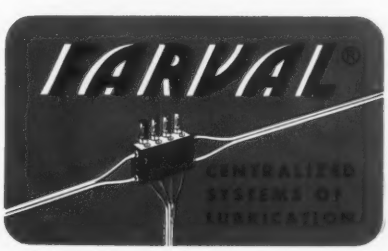
The Farval Corporation, 3267 East 80th Street, Cleveland 4, Ohio.

® Reg. U.S.Pat. Off.

Affiliate of The Cleveland Worm & Gear Company (Subsidiary of Eaton Manufacturing Company)

KEYS TO ADEQUATE LUBRICATION

Wherever you see the sign of Farval—familiar valve manifolds dual lubricant lines and central pumping station—you know steel mill equipment is being properly lubricated.



Machinecraft gets .0005" tolerances with Cities Service Chillo Cutting oils!

Machinecraft, Inc., of Whitman, Massachusetts, makes a product that is surely the answer to many a textile man's fondest wish.

In place of old-style solid arbor top rolls, which often drip lubricant onto the fabric, Machinecraft has developed "the anti-friction top roll."

Operating on ball bearings, this unique invention requires almost no lubrication, therefore eliminates staining problems. In addition, it permits higher speeds of operation and produces more uniformly woven fabric.

In all of this, extremely intricate machining is required —and Cities Service Chillo Cutting Oil plays a crucial role.

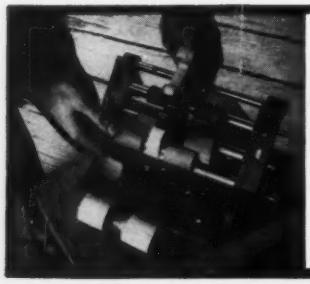
Using Cities Service Chillo "A," Machinecraft is actually achieving tolerances as fine as .0005"! Moreover, Machinecraft reports that Chillo "A" gives "excellent tool life, produces a fine finish, has unusual stability, and offers continuous quality from batch to batch."

"In addition," continues this well known firm, "Cities Service provides us with exceptional technical assistance and good delivery service."

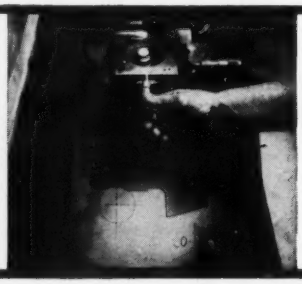
There's little to add to what Machinecraft says except a reminder that *you* can expect similar results with Cities Service, too. Talk with a lubrication engineer from the nearest office. Or write: Cities Service Oil Company, Sixty Wall Tower, New York 5, N. Y.

CITIES SERVICE

QUALITY PETROLEUM PRODUCTS



Machinecraft's Anti-Friction Top Roll is rapidly replacing old-style solid arbor type top rolls in textile mills. It prevents staining, permits greater operating speeds.



Shadowgraph is method of checking accuracy of precision machined parts for anti-friction top roll. Machine magnifies and projects the part's shadow outline. Tolerances are as fine as .0005".

Volume 16, No. 2
February, 1960

Lubrication Engineering

DESIGN RESEARCH APPLICATION EDUCATION MAINTENANCE

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LUBRICATION IN THE NEWS

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Graduate Salaries To Increase

In 1960, companies expect to pay an average of $499.00 per month for B.S. graduates and $437.00 per month for B.S./B.A. non-technical graduates according to the Midwest College Placement Association. This annual college recruiting survey report is based on returns from 225 companies. Last year the companies estimated the 1958-59 average at $478.00, but it turned out to be $490.00, a 4.5 per cent increase rather than the 1.9 per cent increase that had been expected. Based on the assumption that salary increases are usually higher than estimates, B.S. graduates may hit a $500.00 average for 1960.

The highest salary offers for B.S. graduates were from the aircraft and parts research firms ($521.00). Aircraft also led the industry list for highest salaries for M.S. degrees ($630.00) and Ph.D. ($873.00).

The chemical and allied products industries plan the largest number of college recruiting visits, followed by the electronics, electrical machinery and equipment group. Companies recruiting technical personnel made an offer to approximately one out of every five interviewees. Eighty-nine per cent of the need for technical personnel was met in 1958 and one of the reasons for quotas not being filled was the continued high selectivity on the part of the companies.

CBBI Plans 1960 Meeting

The 1960 Annual Meeting of the Cast Bronze Bearing Institute will be held October 12 at the Grove Park Inn, Asheville, N. C., according to Wm. H. Crossman, assistant secretary-treasurer, Randall Graphite Bearings, Inc., Lima, Ohio, national president of CBBI. The meeting immediately precedes the annual meeting of the Non-Ferrous Founders' Society October 13-15 at the same location.

The Cast Bronze Bearing Institute, an affiliate of NFFS, is the technical and educational organization of cast bronze bearing producers. Soon to be released by CBBI is a manual on design and application of cast bronze bearings based in part on new design data and methods of the Friction & Lubrication Section, Franklin Institute, Philadelphia, which prepared the new manual under CBBI sponsorship.

Engineer Need Anticipated

A recent newsletter of the Government Office of Education revealed final data on engineering degrees during the academic year 1958-59.

BS Degrees	38,162
MS Degrees	6,761
Ph.D. Degrees	713

These represent increases over 1957-58 of 10% at the BS level; 16% for MS and 10% for Ph.D. The graduate degree trends are encouraging particularly in view of the drop from earlier estimates of Bachelor Degrees, due to increased drop-outs.

Meanwhile, there is evidence of a decline in freshman enrollment for the fall of 1959, which the Commissions will discuss in detail when the information is compiled by the Office of Education which is expected this month.

This comes at a time when demand for engineers is again increasing. Results from the 1959 EMC Demand for Engineers survey—just completed—indicates that industry anticipates recruiting an increased number of engineering graduates in the 1960's when the current freshman class would graduate. By 1963, 12 engineers will be sought for every 10 recruited in 1959; by 1966, 15 for every 10. In certain industries, this ratio is much higher, such as electrical equipment and electronics, research and development; aircraft, and telecommunications.

The Demand Report will be available shortly on request from the Engineering Manpower Commission, 29 West 39 Street, New York 18, New York.

Begin Third Grease Survey

The third annual survey on production of lubricating greases and fluid gear lubricants will begin in January, it was announced by the National Lubricating Grease Institute. Data will be collected on production for 1959 in the only industry gathering of its kind.

Institute members expect a sizable gain in 1959 poundage over the recession total given in 1958. About 85 per cent of United States production is shown each year, it is estimated, while the Canadian totals are unofficially pegged at a slightly lower percentage. More than a billion pounds of lubricants were produced by the two countries in 1958, the last survey showed.

Forms are sent to NLGI manufacturing members in January. Final tabulations are made at the end of March. The survey was instituted three years ago to enable all classifications of membership to note historical trends in types of thickeners, and as a public service.

J.W. Peterson New ASLE Treasurer

Mr. J. W. Peterson, Standard Oil Co. (Indiana) was recently elected ASLE Treasurer to fill the unexpired portion of C. C. Blaisdell's term. Mr. Blaisdell was to have served until April, 1960. Prior to his election, Mr. Peterson formerly served as ASLE Treasurer during the period 1956-59, and has been serving as temporary assistant Treasurer of the Society since October, 1959.

Defense Aide Urges Standards

Industry standards, specifications, and practices will be adopted wherever possible by the Department of Defense whenever possible, according to Perkins McGuire, Assistant Secretary of Defense for supply and logistics.

Mr. McGuire made the announcement in an address at the annual meeting of the American Standards Association, the national coordinating body for voluntary standardization. The meeting was held at the Plaza Hotel, New York City, December 9.

The new procedures and policies for military standardization, Mr. McGuire said, will help reduce costs of military

purchases and stocks. Much progress has already been made on the standardization program, he added, but further improvements are contemplated.

As a result of the Defense Standardization Act passed in 1952, the number of different items used and stocked was reduced considerably—engine accessories from 2,300 to 78; tires and tubes from 1750 to 95; rivets from 5900 to 211.

"If you consider that we save about one million dollars a year in management expenses for every 1,000 items eliminated from our supply system, you may get an idea of the attendant savings in such a standardization effort," said Mr. McGuire.

The assistant secretary estimated that the military carries supplies valued at about $47 billion in depots and warehouses throughout the world. Each year about $15 billion worth of supplies are used and replaced by an equivalent amount.

One of the most significant achievements of the standardization program has been the complete identification and cataloging of this supply under a single system, Mr. McGuire thinks. The cataloging revealed that the military stocks about 3½ million different items made by more than 34,000 different companies. More than 500,000 new items enter the system every year, and an equal number is eliminated.

However, the standardization program does not run entirely smoothly yet, the speaker admitted. An analysis of a study conducted earlier this year by the American Standards Association on behalf of the Department of Defense and a parallel study by the Department itself revealed several areas that could be improved.

Some of the conclusions drawn from this analysis are these: (1) the military should concentrate its standards work on high priority items and avoid giving equal attention to inconsequential projects involving only small purchases; (2) an engineering standardization program should be actively pursued at the development and drawing board stage to preclude the end for standardization when the finished products have entered the supply system; (3) the military should not duplicate industry standards.

"In the future, wherever possible, we intend to adopt industry specifications, standards and practices whenever they will meet our needs," Mr. McGuire said in conclusion.

Company Program Aids Education

Grants totaling more than $1,300,000 have been awarded to 143 universities and colleges in the Du Pont Company's annual program of aid to education, the company announced today.

The program is for fundamental research by universities, for strengthening the teaching of science and related subjects, and for facilities for education or research in science and engineering.

The largest part of the program is to help strengthen the education of scientists and engineers. Grants totaling $580,000 were awarded for the 1960-61 academic year to more than 100 colleges and universities to support the teaching of science and mathematics as well as other liberal arts subjects; for education and research in biochemistry in medical schools; and for postgraduate teaching awards and scholarships for prospective high school teachers of science and mathematics.

Grants for fundamental research in 1960-61 totaled $475,000 for 37 universities. These are for unrestricted research in the physical sciences, including chemistry, chemical engineering, physics, mechanical engineering, and metallurgy. They range from $5,000 to $20,000. The institutions may use them any way they wish, including the support of graduate students. The universities determine the research to be undertaken and are free to publish the results. An additional $43,200 was awarded for 24 summer research grants to enable individual staff members of 21 universities to undertake research of their own choosing during the summer.

A $250,000 fund was authorized for capital grants for science and engineering facilities. This provided awards to 12 independently controlled institutions. Ranging from $5,000 to $50,000 each, these are grants to help with the cost of new buildings, equipment, or renovation of existing facilities.

INDUSTRY NOTES

In a move toward further corporate integration, Eaton Manufacturing Company today announced that its wholly owned subsidiary, The Cleveland Worm & Gear Company, and the latter's subsidiary, The Farval Corporation, will become divisions of Eaton under their present respective names, effective January 1, 1960.

At the same time, George H. Acker, president of Cleveland Worm & Gear and Farval, has been appointed general manager of the two divisions with full administrative responsibilities, it was announced by Wm. A. Mattie, Eaton vice president-administrative.

(*Con't. on p. 88*)

SECTION NEWS

Chicago—Guest speaker at the regular January meeting was R. K. Sedgewick of the Kearney & Trecker Company, whose talk on the problems of controlling friction in the design of machine tools coincided with the publication of his paper on this same subject in the January issue of LUBRICATION ENGINEERING. An added special feature of the evening was George Spehn's report on the 1959 Rose Bowl Game. George was head linesman at the game. . . . **Huntington-Charleston**—The first meeting of the year was held at Humphreys Restaurant in Charleston, and featured E. W. Brennan of the Pure Oil Company's Research Center at Crystal Lake, Illinois. The subject of Mr. Brennan's talk was "Petroleum Hydraulic Oils" and covered the desirable characteristics of these oils and the methods of measuring them. . . . **New York**—N. R. Hostler of the Tidewater Oil Company spoke on "A Practical Discussion of Lubricating Oils and Greases at the January meeting. The talk covered: lubricant selection; oil classifications; the fallacy of looking only at physical properties; importance of additives; the importance of chemical, thermal and solvent properties; grease classifications; the role of grease structures; and grease additives. . . . **Rochester**—The January 13 meeting was designated Past Chairman's Night at which past chairmen were recognized for their efforts. E. H. Berg of the Esso Standard Oil Company gave a talk on "Complex Calcium Greases". . . . **Syracuse**—The January 18 meeting featured William Kite and R. J. Ronan of the Texas Oil Company as speakers. The topic was "Evaluating Automotive Transmission Fluids" and proved to be both timely and interesting in view of the current interest in automotive and industrial fluids due to the conflicting opinions between various industries and government specified lubricants.

Louis M. Fleming, Cities Service Oil Company, the current Twin City Section Chairman (left) awarding an achievement plaque to Donald J. Armstrong, Farmers Union Central Exchange, Inc., retiring Twin City Section Chairman.

Great Names in Steel Making

OSCAR L. MAAG, *recipient of the ASLE National Award in 1956, was preeminently a lubrication engineer. Yet every mill in America that operates on roller bearings testifies to Oscar Maag's contribution to modern steel making.*

As sometimes happens in the initial trial of a new process or material, the first test of roller bearings in a rolling mill was quite successful. But as soon as increased speed and pressure were attempted, in a second installation, serious trouble developed.

The big Timken bearings (they measured 30″x16″ in diameter) were taken back to the company's plant at Canton, Ohio, where they were lapped and studied on the test stand. The cause of failure was in the calcium soap grease used to lubricate the bearings. Furthermore, it was evident that no type of lubricant then available was capable of handling the load.

At that critical moment Oscar Maag, Timken's lubrication specialist, had an inspiration. Experimentally, he added sulphur chlorinated base cutting oil to the grease.

It was the first E. P. (extreme pressure) lubricant applied to rolling mill bearings, and it worked perfectly. Not only did it solve the immediate problem—it cleared the way for development of roller bearing mills in which speeds exceeding a mile-a-minute and pressures to 25,000 psi are successfully handled by today's Ironsides "E.P." lubricants.

We were privileged, here at Ironsides, to work closely with Oscar Maag. He was our Company's consultant following his retirement from Timken. We knew him as both a great technologist and a good friend. As specialist for nearly 70 years in lubricants for steel making, it is appropriate that we should now honor Oscar Maag for his contributions to the industry we serve. The Ironsides Company, Columbus 16, Ohio.

J.S. MARCUSES

1960 Report— How Baragel* and Baragel*24 improve grease efficiency

BARAGEL extends versatility as a non-soap gelling agent

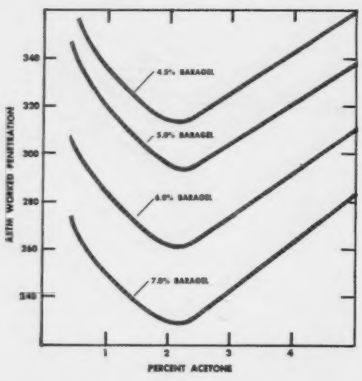
Among the non-soap gelling agents used by grease compounders, BARAGEL has been coming to the fore as a versatile gelling material. Lubricating greases made with this product of Baroid Chemicals, Inc., show practically no change under extremes of heat, cold or moisture.

Technically, BARAGEL is a reaction product of mixed organic ammonium halides and refined sodium montmorillonite. A common organic antioxidant is included in the reaction mixture to provide built-in oxidation inhibiting properties.

As its chemical nature indicates, BARAGEL is a member of the BENTONE* family of products. BENTONE 34 has been outstandingly successful in lubricating greases, paint, plastics, inks and other fields. Experience indicated that even further efficiency could be achieved by tailoring the product to suit a specific application. BARAGEL is the result of research directed to make the product meet the needs of the lubricating grease industry.

BARAGEL efficient in greases made with high VI oils

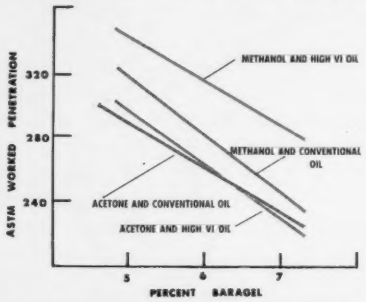
BARAGEL has proved to be efficient in greases compounded with all types of petroleum oils, including solvent refined, high VI oils. Tests were made with a base oil of 30.4° API gravity at 60° F and a viscosity of 356 SUS at 100° F.



BARAGEL was stirred into the oil, acetone added and stirred, and the mixture was milled. Greases having an ASTM worked penetration in the 315 range required about 4.5% BARAGEL, while greases in the 280 range required about 5.5% BARAGEL. Data Sheet A-1, available on request, gives full details of this test.

BARAGEL works efficiently with wide range of dispersing aids

As a grease gelling agent, BARAGEL works well in oils of low, medium or high viscosity, where the dispersion aid is either acteone or methanol. The influence of the dispersion aid may vary between different



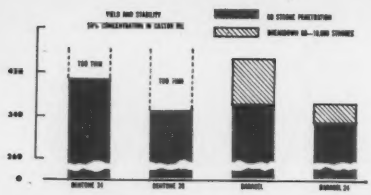
oils. The chart shown here illustrates the changes resulting from use of oils of varying viscosity.

It will be noted that the influence of acetone on yield at optimum concentration is essentially the same for both a conventionally refined oil and a highly refined, high VI oil. There is, however, a marked difference in the influence of methanol on yield at optimum concentration in the same two oils.

Complete details of a series of conclusions drawn from tests are available on BARAGEL Data Sheet A-8.

Greases made with castor oil

BARAGEL 24 has been proved by tests to be exceptionally efficient in thickening castor oil. Greases prepared with BARAGEL 24 are also much more stable to working in the ASTM grease worker.



Tests were made to compare results when thickening greases with BENTONE 34, BENTONE 38, BARAGEL and BARAGEL 24. The results are shown in the accompanying chart and details are available in Data Sheet A-5.

Worked penetrations of greases made with castor oil and 10% BARAGEL 24 were 325, with a penetration of 365 after working 10,000 strokes.

BARAGEL 24 improves efficiency in non-petroleum oils

Just as BARAGEL was the result of specialized research to make BENTONE 34 even more effective as a grease gelling agent, in the same manner BARAGEL 24 has been developed as an improvement over BARAGEL in thickening greases made with non-petroleum oils.

BARAGEL 24 works unusually well in compounding greases made from such non-petroleum oils as polyalkylene glycols, di-2-ethylhexyl sebacate, di-2-ethylhexyl adipate and castor oil. While BARAGEL 24 may not find widespread use in thickening most petroleum oils, it is possible that BARAGEL 24 may prove to be best for certain specific petroleum oils.

The improved efficiency of BARAGEL 24 in non-petroleum oils has been achieved primarily through the nature of the organic ammonium halide used. The inorganic portion of the product is refined sodium montmorillonite.

BAROID

BAROID CHEMICALS, INC.

A SUBSIDIARY OF NATIONAL LEAD COMPANY

[illegible] SOUTH COAST LIFE BLDG.

HOUSTON 2, TEXAS

*Trademark of National Lead Company for an organic ammonium montmorillonite.

LETTERS TO THE EDITOR

Lubrication Engineering welcomes the comments and suggestions of readers with regard to articles published in its pages or concerning topics of interest to those engaged in any phase of lubrication engineering. Letters received cannot be acknowledged, but those felt to be of interest to other readers will be published. The Society will not be responsible for the statements or opinions expressed.

Sir:

It has been several years now since plans were made for publishing a complete Lubrication Engineering Handbook, sponsored by the A.S.L.E. At the Annual Meeting in Buffalo it became apparent that many of our members were either unaware of the Handbook project or had erroneous ideas concerning it. I felt that a concise resumé might be in order.

Because there is, today, no modern, technical Handbook of Lubrication Engineering available, a project to develop one was set up in 1954. In order to guarantee that it would be of first class quality, publishers of Technical Handbooks were approached with a cooperative program in mind. After considerable investigation we accepted the offer of McGraw-Hill Publishing Company to edit and publish such a Handbook in conjunction with A.S.L.E. Mr. J. J. O'Connor, Managing Editor of "Power" Magazine, assumed the responsibility as Editor of the Handbook and Mr. John Boyd was chosen as the Technical Consultant for A.S.L.E. whose prime responsibility was to make certain that technical content was correct.

The task of developing an outline covering every phase of the art and practice of Lubrication was undertaken by a committee of A.S.L.E. members who were outstanding in their respective fields. After more than a year of hard work an outline was established and the Handbook divided into 4 separate parts:

Part 1—Lubrication Principles
Part 2—General Lubrication—Engineering Practice
Part 3—Lubrication of Specific Equipment
Part 4—Lubrication in Major Industries

The next task confronting the Advisory Committee was that of recommending responsible authors, experts in their fields, to write the various segments of the Handbook. Again this consumed considerable time but today there are 73 such authors working on their parts of the Handbook and these are distributed as follows:

Part 1—26 Authors
Part 2—22 "
Part 3—13 "
Part 4—12 "

The Handbook should have approximately 1,000 pages and will be of the size generally assumed for such a work, about 6" x 9". It is our firm belief that the A.S.L.E.-sponsored McGraw-Hill Handbook will be a complete source of general and specific data pertaining to the field of lubrication engineering. It will appeal to those engaged solely in research work as well as those who are in contact with the art on a casual basis. It should be a storehouse of knowledge about modern principles of lubrication.

The task of assembling the finished manuscripts is arduous and time-consuming. The various authors are men whose time for composing such articles is very limited due to pressure imposed by their own daily tasks. They have been most cooperative, however, and it is hoped that a finished Handbook can be made available during 1961.

Sincerely yours,

C. R. Schmitt, Chairman,
Handbook Advisory Committee
E. F. Houghton Company
Philadelphia, Pa.

NEXT MONTH ! !

SPECIAL . . . . .

Believing that there is a need for a unified treatment which would assemble the scattered and diverse information on lubricating methods, the Society commissioned Allan Brewer to prepare a comprehensive review of the methods by which lubricants are applied. In a series of articles—beginning next month—the pertinent characteristics of the various methods will be discussed and, through liberal use of illustrations by Robert Wayne, the various lubricating devices will be described.

ALSO . . . . .

Rapid Determination of Heat Capacity of Liquids Over Extended Temperature Ranges

The removal of heat from bearing surfaces is a function of the heat capacity and thermal conductivity of the lubricant. Intelligent equipment design requires a knowledge of these properties. A rapid method of measuring heat capacities over an extended temperature range will be described. Design and operation of a simplified semi-adiabatic calorimeter, and a unique method of calculation outlined.

Some Considerations in the Selection and Use of Water Soluble Cutting and Grinding Fluids.

Water soluble products offered to industry vary considerably in physical and chemical makeup. This review will show that the non-cutting or grinding functions of such products must also be considered in an evaluation for production use.

Predicting Grease Performance from Capillary Viscometry Data

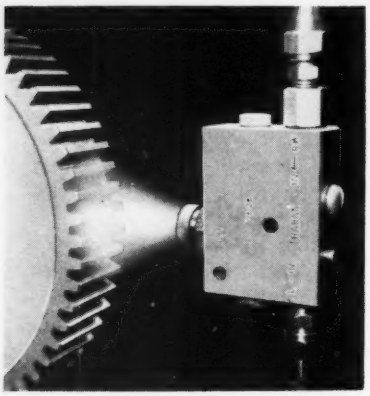
Apparent viscosity changes can be attributed in part to a failure to correct for "end-effects" characteristic of efflux-type viscometry. A method for utilizing these end-effect corrections to predict the performance of a grease in a centralized lubrication system from capillary viscometry data will be described.

NEW PRODUCTS

The Society will not be responsible for the accuracy of statements made in this column. Any reference to proprietary products does not imply an endorsement of such products by the Society.

NEW SPRAY VALVE ANNOUNCED

The addition of an Air Lube Gear Spray Valve for use with centralized lubricating systems has been announced by Trabon Engineering Corporation, 28815 Aurora Road, Solon, Ohio.



The valve, which requires only 15 to 25 pounds of air pressure for proper spray results, automatically shuts off air when lubricant feed shuts off. The combination of low pressure and quick automatic shut-off is said to result in substantial savings in air and lubricant.

Because of its design the Trabon gear-spray valve requires no adjustment of spring tension to meet varying conditions of lubricant viscosity or temperature. Oils and all greases suitable for pumping may be used.

The valve can be used with centralized systems specifically planned for gear lubrication only, or added to existing systems where a switch to "all-purpose" lubricant permits both gears and bearings to be served by the same pump.

When used with a Trabon centralized system, the spray valve design is said to provide another unique feature. It automatically gives warning at the pump due to air failure or nozzle blockage.

SELF-WICKING LUBRICANT FOR BEARINGS

Lifetime lubricated sleeve bearings, eliminating the conventional oiler hole, could theoretically be designed through the use of a self-wicking lubricant, Permawick Co., Detroit, reports.

Sleeve bearings lubricated with self-wicking lubricant are also reported to be exceptionally resistant to extreme moisture and cold conditions. The bearings perform satisfactorily at continuous temperatures to 200°F and under high loading. Pour point of the Permawick 265 formulation is −25°F.

Because the oil and wicking combination is less than half the volume of a comparable felt wick and oil dam, bearing reservoirs may be substantially reduced in design. The new lubricant may be injected automatically during bearing assembly.

Used principally to date in fractional horse power motors, the self-wicking lubricant will also find application on sleeve bearings and pillow blocks in integral horsepower motors, blowers, pumps, farm equipment, generators, presses, gasoline engines and lifts, Permawick Co. states. It is also recommended for use with sintered bearings.

The Permawick material is a combination of oil and minutely particled cellulose fibers which has the feel and appearance of a grease but is more than 85% fine lubricating oil by weight and occupies little more volume than the contained oil.

The oil and wick combination is said to be stable under conditions of extreme moisture, cold, overheating or oxidizing atmospheres and highly resistant to aging. Permawick lubricated bearings examined after seven years showed no separation of oil and wicking. For further information write: Permawick Company, 5319 E. Outer Drive, Detroit 34, Michigan.

SOLID FILM LUBE OFFERED

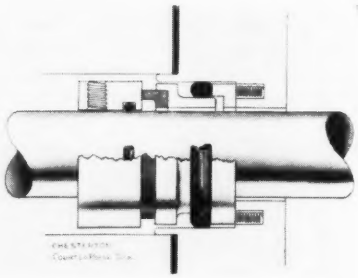
A unique development in the field of solid film lubrication has recently been announced. This type of lubrication has been known and utilized in critical military applications for many years. However it has not previously found wide industrial acceptance because of prohibitive initial cost and the need for expensive surface pre-treatment.

This formulation of molybdenum disulfide, Proxylube, is applied by any of the usual methods of painting such as spraying, brushing, or dipping. The dried film reportedly provides permanent lubrication on all types of rotating and sliding bearing surfaces.

Poxylube is said to produce outstanding lubricity, and formerly unobtained adhesion, to metals with no more surface preparation than simple degreasing. This property enables industrial users to adapt this unusual lubricating system to existing products without major production modification.

For further information, write to: Poly Chem, 541 S. Webster, Indianapolis 19, Indiana.

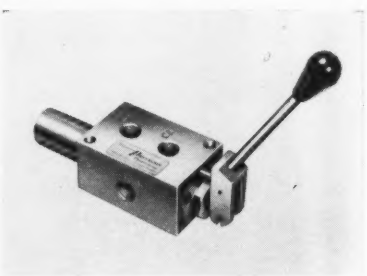
SPRINGLESS SHAFT SEAL



A new seal is reported to give positive and durable sealing by using balanced fluid pressure to replace operational springs. CounterPoise springs are employed only to keep the deep carbon faces in contact when pump shutdown or pressure is reduced below operational level. In CounterPoise the use of hydraulic pressure eliminates need for spring closing. Excessive and uneven face wear is eliminated. The conventional rotary mass is replaced by a single ring reportedly cutting down excessive stuffing box turbulence. It is designed for easy installation by maintenance men since one standard design is used for all pressures. No sleeve or shoulder is required for high pressures. Brochure describing Chesterton's new concept of springless sealing for widest range of fluids, corrosives or other service problems is available on request. A. W. Chesterton Co., 6 Ashland St., Everett 49, Mass.

FOUR-WAY VALVE ANNOUNCED

A miniature four-way directional control valve with a sliding spool construction has been announced by Sarasota Precision Products, Inc.



Designed especially for use in small hydraulic circuits, under 3 gpm, this new valve is only 2″×1½″×5″ (plus handle) and weighs one pound and two ounces.

NEW PRODUCTS
(Continued)

The new Sarasota valve is said to offer several advantages. It has a low pressure drop of approximately 13 psi at a rated capacity of 3 gpm, and a low internal leakage of less than 10 cubic inches per minute at 2000 psi with 150 ssu oil.

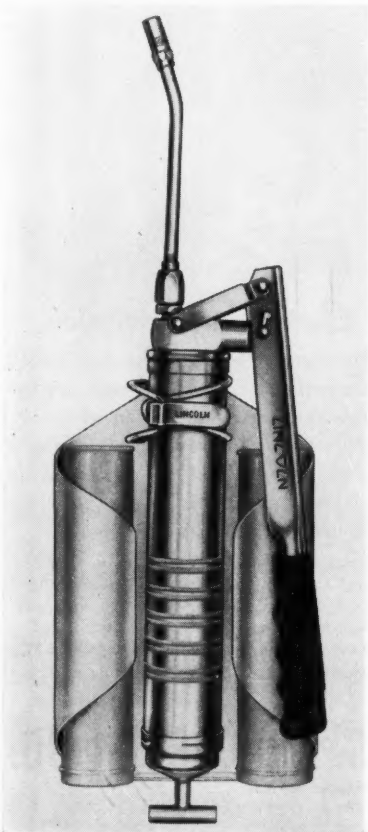
The balanced spool is of hard-coated aluminum which reportedly provides great wear resistance. The valve is available with standard ⅛ inch and ¼ inch dry seal pipe threads. Special porting or manifold mounting can be made to order.

Additional information and complete specifications for your individual requirements may be obtained by writing Sarasota Precision Products, Inc., 5757 McIntosh Road, Route #1, Sarasota, Florida.

NEW LEVER-TYPE GREASE GUN

A new lever-type grease gun that provides either high pressure or volume delivery of lubricant by means of a shifting device has been developed by Lincoln Engineering Company of St. Louis.

To change pressure ratios it is only necessary to shift a latch pin in the handle from one slot to another. Manufacturer stated that pressures up to 10,000 p.s.i. can be achieved in the high pressure position, and full pressure can be obtained with a stroke length as small as ¼" to facilitate working in close quarters.



The Lincoln Gun incorporates a nozzle extension that swivels 360° permitting easy access to hard-to-reach fittings. Equipped with hand-fitting, grease resistant rubber pistol grip.

Gun is of all steel construction with rust-resistant, high satin finish nickel plating. It can be loaded three ways; with standard 14½ oz. grease cartridge, with Lincoln filler pump, or by suction. Overall length is 20" with a barrel diameter of 2¼".

For additional information and prices on these new items write for Bulletin No. 230, Lincoln Engineering Co., 4010 Goodfellow Blvd., St. Louis 20, Mo.

HEAVY DUTY BEARINGS FEATURE INCREASED CAPACITY

Load capacities from 19% to 55% greater than equivalent size Conrad type bearings are said to be obtainable by using the new precision type HDR radial ball bearings now available from SPLIT BALLBEARING, Div. of MPB, Inc., Lebanon, N. H.

The increased load capacity may also be expressed in terms of increased life expectancy—up to 298% greater. The bearings also are said to be more rigid, with an average of 20% less radial deflection than equivalent types.

These performance advantages result from the unique Split Ball-bearing single-fracture design which utilizes maximum ball complements. The new bearings have two to six more balls per bearing than equivalent bearings. The manufacturing method consists of fracturing the outer ring of the bearing at one point, spreading it sufficiently to allow the assembly of a maximum complement of balls. Full depth, symmetrical raceways with no loading slots permit HDR bearings to carry thrust loads from either direction. The one-piece, outer landriding bronze retainer is said to have high strength, improve internal lubrication, and permit higher operating speeds than possible with more conventional designs.

Offered in ABEC-3 and ABEC-5 precision grades, the new bearings are made in *Extremely Light, Extra Light, Light,* and *Medium Series,* in metric sizes up to 85 mm O.D. Standard material for rings and balls is 52100 steel. Four ranges of internal clearance allow designers a wide variety of operating characteristics.

Complete engineering information on the HDR series is available in Catalog 60, available on request from Split Ballbearing.

PERSONALS

L. Paul Dougherty and Jack Doyle have been added to the Organic Chemical sales staff of Emery Industries, Inc. Mr. Dougherty will be assigned to the New England sales territory, while Mr. Doyle will cover a territory that includes West Virginia, southeastern Ohio, western Pennsylvania, and western New York State.

Richard J. Hefler, Vice President, Finance, of American Potash & Chemical Corp., has been elected to the company's board of directors.

J. Richard Sayers of St. Louis has been appointed Assistant Director of Monsanto Chemical Company's Purchasing and Traffic Department.

Edward E. Frick and Albert S. Mancini have been appointed to executive positions with Micro-Lube. Frick has been named General Manager and Mancini has been appointed national Sales Manager.

Ernest N. Robinson has been appointed General Manager of the Alemite and Instrument Division of Stewart-Warner Corp.

Charles H. Hacker has been named to the newly created post of Chief Engineer Industrial Filters of the Pall Corp.

Charles J. Chapman has been named Vice President, Marketing for National Carbon Co., division of Union Carbide Corp. Mr. Chapman has been director of marketing for National Carbon since 1957.

Brooks Oil Co. announced the election of Fred H. McCurdy to the offices of Chairman of the Board and Chairman of the Executive Committee; W. W. Ward to President and Chief Executive Officer; R. T. Joyce to Vice President in charge of Operations and Secretary; and **Alfred E. Paul** to Vice President, Engineering and Sales.

Adam Cook's Sons, Inc. has announced the appointment of Benjamin C. Price to the position of Wholesale Division Sales Manager; Charles E. Killmer to handle industrial sales of specialty oils and lubricants in the northeastern New York area; and Charles B. Dwyer as Industrial Division Sales Manager.

Bunting Brass and Bronze Co. announced the appointment of William H. Searles to Treasurer succeeding Walter F. Volk who continues as Vice President. Ralph A. Schaefer, Director of Research and Development has been named director of an enlarged department of engineering and research.

Oronite Chemical Co., a subsidiary of the Standard Oil Co. of California, has appointed R. D. Stayner its Eastern Sales Manager of the newly created Industrial Chemicals Division.

How to increase the life of your air tools and cylinders

. . . Norgren Lubro-Control Units reduce wear, improve equipment performance and cut maintenance costs.

To get maximum life from your air tools and other pneumatic devices, it is essential to filter the compressed air, control its pressure and to provide proper lubrication.

Filter removes abrasive solids and corrosive liquids

Compressed air as it comes directly from an air line generally carries with it dirt, pipe scale, rust and various liquids. If these substances are allowed to be carried by the air into your air tools, cylinders and other air-operated equipment, they will cause excessive wear and corrosion. The operating life of your air-devices will be cut short, and maintenance costs will be high. An air line filter must be used to remove these abrasive solids and corrosive liquids from the compressed air.

Regulator controls pressure

The fluctuating pressure of your compressed air system should be controlled by a pressure regulator. The regulator holds the pressure constant at the working pressure at which the pneumatic equipment will operate most efficiently.

Micro-Fog Lubrication ideal for air-equipment

Finally—and most important—pneumatic equipment must be given the right amount of lubrication. The best way to provide this lubrication is to put a lubricant into the air stream that powers the equipment.

A Micro-Fog Lubricator injects a fog of extremely fine particles of oil automatically and continuously into the air stream. It can be adjusted to meter just the right amount of oil for proper lubrication.

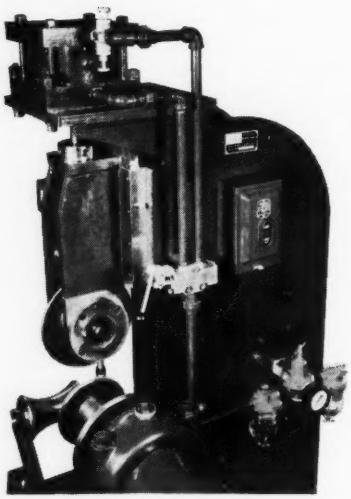
Micro-Fog particles are extremely fine. When injected into the air stream, they are like dry smoke until they reach the point to be lubricated. Because of this, Micro-Fog can be conveyed long distances and through complex piping systems without condensing into larger oil particles in the air line.

Norgren Lubro-Control Unit:

This unit consists of:

1. An air line filter.
2. A pressure regulator.
3. A Micro-Fog Lubricator.

It gives you these important benefits: better equipment performance, less wear, longer service life, less down time, lower maintenance costs.



The Norgren Lubro-Control Unit on this pipe cutting machine keeps the air cylinders operating at top efficiency. Without the Norgren unit, it was found virtually impossible to get the close control that is vital to the operation of the machine.

FOR COMPLETE INFORMATION, **call your nearby Norgren Representative, listed in your telephone directory — or WRITE FOR DESCRIPTIVE LITERATURE.**

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PRODUCT LITERATURE

BROCHURE LISTS PROPERTIES OF CAST BRONZE ALLOYS

The chemical and physical specifications of 29 cast bronze alloys are compiled in a new brochure published by Renewal Service Inc., Philadelphia manufacturer of sleeve bearings and bushings. The alloys listed are those most widely used in these products.

A feature of the brochure is a chart indicating the compressive strengths of selected alloys and how these properties vary with the thickness of the metal. This chart is stressed because bearings are almost universally used in compression yet they are seldom specified by compressive values.

Also included is a comparative listing of the latest Military, SAE, Navy, Aeronautical, ASTM, and Federal specifications for the 29 alloys. Copies may be obtained from Renewal Service Inc., 17th & Lehigh Avenues, Phila. 32, Pa.

DATA ON STAINLESS STEEL FILTERS AVAILABLE

New, revised literature on porous stainless steel filters is available from Micro Metallic Division of Pall Corporation, Glen Cove, N. Y. The literature includes information on properties of porous stainless steel. Full specifications are included on standard filters manfactured by the company, and a number of new filter types and sizes are presented.

A feature of the literature are photographs and descriptions of many of the types of custom-designed filters and filter elements. Detailed technical data is included to permit direct ordering of stock units.

The bulletin, Release M-212A, is free upon request.

DATA ON ACID HANDLING AVAILABLE

Monsanto Chemical Company's Inorganic Chemicals Division has announced the publication of three technical bulletins covering the bulk handling and storage of sulfuric acid and oleum (I-182), chlorosulfonic acid (I-181) and muriatic acid (I-183).

The illustrated bulletins are designed to give technical assistance in setting up safe procedures in the bulk unloading, handling and storage of the materials. Each publication covers shipments, tank car dome fittings, tank truck pipe fittings, factors to consider in determining storage tank sizes, construction materials, level indication, tank car and tank truck unloading methods, product sampling, safety factors, etc.

Copies of the technical bulletins are available free from the Inorganic Chemicals Division, Monsanto Chemical Company, 800 North Lindbergh Blvd., St. Louis 66, Mo.

CAST POLYETHYLENE FILM DISCUSSED IN BROCHURE

The latest developments in cast polyethylene film are described in a 12 page booklet, entitled "Cast Film," just released by U. S. Industrial Chemicals Co. Information contained in this brochure is the result of tests and trial runs carried out by U.S.I. in its Polymer Service Laboratories, Tuscola, Illinois. The new booklet deals both with film casting equipment such as chill rolls and dies and a comparison of properties among cast, quenched and blown films.

Use of chill rolls is the main difference between the casting technique and those of water quenched or blown film making systems. It is the chill roll which accounts for the film's excellent optical properties: high clarity, high gloss and low haze.

The booklet discusses processing variables and their effects on film properties and presents tabular data describing physical properties such as yield strength, elongation, film tear strength and friction factor.

Copies of the Technical Data brochure—"Cast Film"—are available upon request to U. S. Industrial Chemicals Co., 99 Park Avenue, New York 16, N. Y.

NEW BROCHURE DESCRIBES METAL PROCESSING EQUIPMENT

To acquaint metal processors with the full line of modern equipment included in its System, Pennsalt Chemicals Corporation has published a new illustrated brochure on its Metal Processing Equipment. The 15-page booklet describes the range of machines, materials and manpower services offered for every type of metal processing requirement.

Included are belt conveyor-type washers, monorail-type conveyor washers, rotary drum washers, sheet steel washers, automatic spray washers, agitating washers, automatic coating machines, automatic phosphatizing machines, drying and paint ovens, paint spray booths, and a number of other machines. The brochure also includes discussion of Pennsalt's complete custom-built finishing systems.

Copies of the new brochure are available from Pennsalt Metal Processing representatives or by writing to Metal Processing Dept., Pennsalt Chemicals Corp., 3 Penn Center, Philadelphia 2, Pa.

UCON

BRAND

fluids and lubricants

UCON heat-transfer fluids do not ordinarily sludge, coke, or gum after months of use at temperatures as high as 450-500°F. Thus, electric immersion heaters and other heat-transfer surfaces stay clean and give long, continuous operation.

UCON heat-transfer fluids have good viscosity stability and low pour points. These properties permit operation over wide temperature ranges yet eliminate cold weather problems and the need for auxiliary heating equipment.

UCON fluids and lubricants also give top performance as:

- Rubber and textile lubricants
- Hydraulic fluids
- Cosmetic components
- Anti-foam agents
- Chemical intermediates

Get the facts. Write for the booklets "UCON Heat Transfer Fluids" and "UCON Fluids and Lubricants."

UNION CARBIDE CHEMICALS COMPANY

DIVISION OF UNION CARBIDE CORPORATION

30 East 42nd Street, New York 17, N. Y.

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A rugged, dependable new shaft seal for a broad variety of applications

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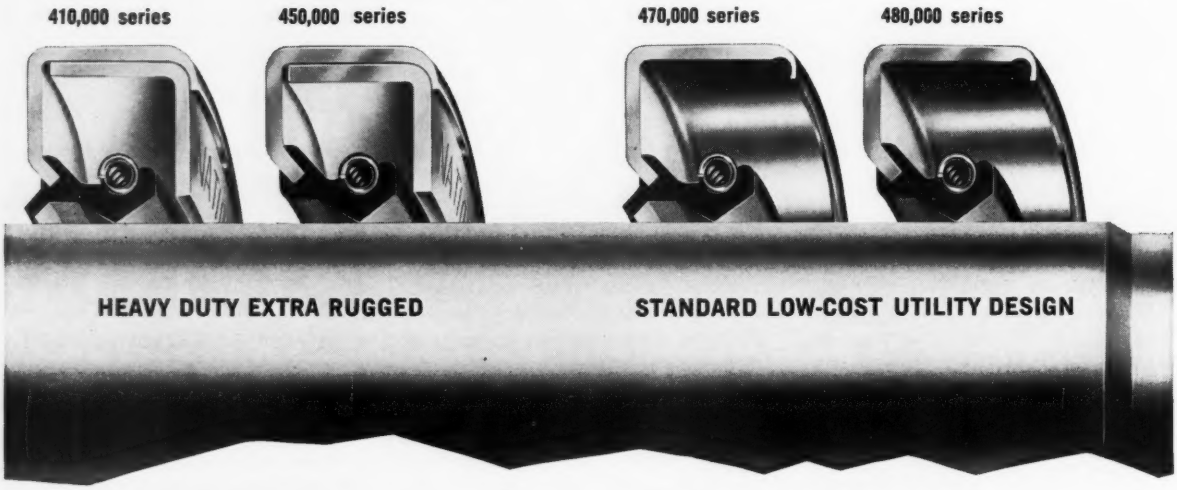

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National Seal engineers — who brought you Syntech® and Micro-Torc* —now offer a ruggedly simple new advance in precision shaft sealing —National BUD (Bonded Universal Design) Oil Seals.

BUD seals are designed for a broad variety of applications, including many where more complex single-lip and double-lip designs were previously specified.

Full details and application engineering help on National BUD or other oil seals are available from your National Seal Division, Field Engineers. See the Yellow Pages under "Oil Seals" or write direct to Redwood City, Calif., home offices.

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NATIONAL SEAL

Division, Federal-Mogul-Bower Bearings, Inc.
General Offices: Redwood City, California
Plants: Van Wert, Ohio; Downey and Redwood City, California.

6071

Vol. 16, No. 2

Lubrication Engineering

annual meeting preview

From all outward appearances, the 1960 ASLE Annual Meeting Program will present attendees with a varied and well-rounded menu. (See pages 78-79). It will be noted that we have scheduled eighteen sessions, including a panel, consisting of fifty-six papers. In summary, the following technical committees and industry councils are sponsoring sessions as follows:

Bearings (3); Engine Lubrication (1); Gear Lubrication (1) plus panel; Hydraulics and Hydraulic Machinery (1); Lubricant Reconditioning and Disposal (1); Lubrication Equipment (1); Lubrication Fundamentals (1); Metalworking (1); Properties of Lubricants (3); Seals and Packings (1); Machine Tool Council (1); National Railroad Council (1); General Session (1).

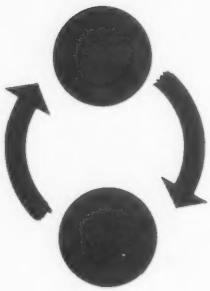
European interest in ASLE programs and activities is demonstrated by papers contributed from England, Germany, Sweden and the USSR.

Special session topics include: "Evaluation of Automotive Gear Lubricants"; "Lubrication of Rolling Contact Bearings at High Temperatures"; "Boundary Conditions of Cavitation Regions in Journal Bearings"; "Teflon Insert Compression Rings in Radial Gas Engines"; "Friction and Wear of Refractory Compounds up to 2000°F"; "Purification of Missile Hydraulic Oil"; "Relation of Friction Characteristics to Automatic Transmission Fluid Operation"; and "Use of Aluminum in Lubrication Systems".

The 1960 Annual Meeting promises to shed new light on many lubrication problems. This *tentative* program outlines the up-to-the minute subjects to be covered at this timely meeting. Look it over and you are sure to find that you can't afford to miss being there. Every effort is being made to insure that papers will be of outstanding quality and interest. We look forward to seeing you in April.

A. W. Lindert
National Program Chairman

Ball bearings have been run in gaseous atmospheres free of oxygen and water vapor and the influence of this environment on bearing performance studied. The gases used in this study included hydrogen, helium and nitrogen-hydrogen mixture. In general, bearing operation was satisfactory in the gaseous environments, provided they were copiously lubricated with petroleum or turbine oils. Bearing surfaces appeared highly polished after running in pure gases. The polishing effect was most noticeable in bearings operated in hydrogen environment—the rubbing surfaces having a finish comparable to a metallographic polish.



The Behavior of Lubricated Ball Bearings in Controlled Atmospheres

by W. A. Glaeser
Battelle Memorial Institute,
Columbus, Ohio

INTRODUCTION

In recent years, bearings have been called upon to operate in many unusual environments—some which seem as far removed from the experience of the lubrication engineer as ice skating is to the Fiji Islander. The atmosphere which surrounds the bearing part is becoming an important parameter to consider in some specialized applications. The peaceful use of nuclear power and the proposed journey of man into space are two areas where operation of bearings in gaseous environments free of oxygen and water vapor or vacuum appear to be inevitable. For instance, in gas cooled package power reactors dry pure gases such as hydrogen, helium, nitrogen, and CO_2 at present apppear to have desirable properties for these applications. The turbine and compressor bearings may be called upon to operate in these gases. Missiles and space vehicles are expected to provide similar oxygen and moisture free environments in the vicinity of running bearings.

Environment is known to have a decided effect upon the physical properties of some materials. These effects have been under study by many separate investigators. For instance, surface films have been found to have a decided effect on the strength of single crystals. (1) It has long been known in salt mines that normally brittle rock salt crystals can be bent and twisted when immersed in warm water. (2) It has not been known, however, until recent years that the strength of these crystals also increases with immersion in water. Bowden, in some experiments on the fundamentals of sliding friction (3) found that carefully cleaned metal surfaces, when slid over one another exhibit tremendous increases in friction when exposed to high vacuum. His studies and the studies of others on the role of adhering films on the frictional properties of bearing materials have dramatically demonstrated the effect of environment on the performance of rubbing surfaces.

Investigation of these phenomena at the author's Institution has been motivated by a practical problem involving ball bearings in rotating machinery. A research program involving the pumping of very pure gases in a closed loop in a research reactor was begun. This study was carried out in conjunction with the development of a gas cooled reactor. The conditions of the tests, simulating proposed reactor operating conditions required that the closed gas system must be free of water vapor and oxygen. Initially, the maximum oxygen concentration allowable was 5 ppm. The gas dew point was not to exceed —100 F and the gas temperature was to be 200 F. The centrifugal compressor required to pump the gas through the test loop was designed to operate in this gaseous environment in a sealed unit submerged in the "swimming pool" at the face of the Battelle Research Reactor. It was required that this unit operate for 10,000 hours without shutdown for maintenance or repairs. The bearings and lubricant are shielded from radiations so that no radiation damage will be incurred by the oil. It is easy to see that if the bearings in this compressor failed, considerable time and money would be lost in shutting down the reactor, removing the loop and cutting open the casing to replace the bearings. The maintenance might have to be done remotely in a "hot cell" making the repair problems virtually insurmountable. Since contact stresses in rolling element bearings are high and sliding does occur, it was considered possible that these bearings might gall or wear excessively in the proposed environment.

Owing to a dearth of information on the operation of ball bearings in pure gaseous environments, a short

Presented before the 14th ASLE Annual Meeting, Buffalo, New York, April, 1959.

term "insurance" program was initiated to study the performance of ball bearings in this environment.

EXPERIMENTAL PROGRAM

Apparatus

The specimens used in these studies were commercial 30 mm self-aligning ball thrust bearings. The upper race was reversed and its flat side lapped and used as a bearing surface. These were operated in the apparatus shown in Fig. 1. A schematic assembly drawing shown in Fig. 2 illustrates the working principles of the apparatus.

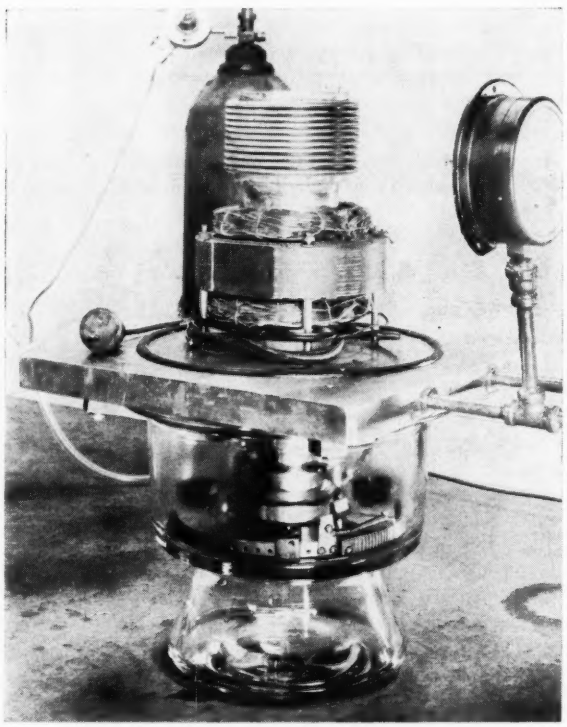


Fig. 1. Apparatus for Evaluating Bearings in Purified Gases.

The apparatus consists of two main parts: the pyrex desiccator adapted for use as an atmosphere chamber and the upper plate and drive motor assembly. The test bearings mounted in the atmosphere chamber are driven and loaded by a shaft positioned by a pair of ball bearings mounted in the upper plate. A "canned rotor" induction motor is used to rotate the shaft. All gas inlet and outlet connections, thermocouple wires, and heater wires pass through sealed channels in the upper plate. The mounting plate is lapped flat and provides a gas tight seal when lowered in place on the ground glass lip of the desiccator. Thrust load is applied to the end of the shaft remote from the test bearings by dead weights applied to a metal bellows welded to the end of the induction motor can. A small thrust bearing in contact with the bellows and the end of the rotating shaft transmits the thrust load to the shaft. The shaft is mounted in support ball bearings with a slip fit through the inner races.

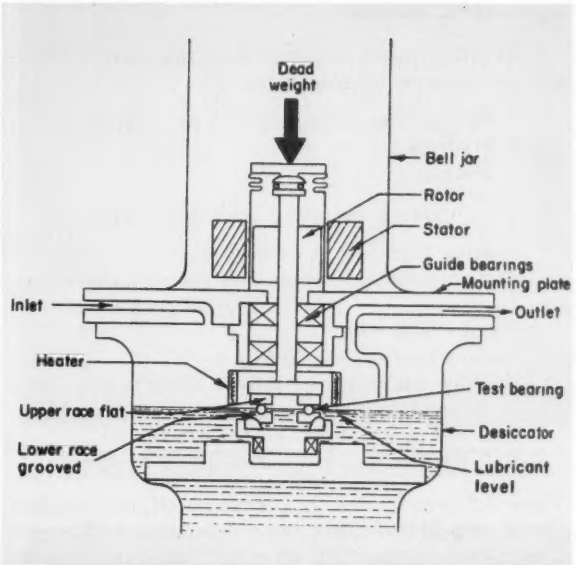


Fig. 2. Schematic Diagram of Controlled Atmosphere Ball-Bearing Evaluation Apparatus.

In assembling the apparatus the lower thrust ring is mounted in the desiccator, the cage and balls placed on the lower race and lubricant added. The lubricant level is established so that it half covers the balls.

The upper mounting plate with the upper thrust race mounted on the shaft is then lowered in place and clamped on the desiccator.

A photograph of a sample thrust bearing used is shown in Fig. 3. The flat side of the upper thrust race bears against the balls and cage assembly which are guided on the grooved lower race. A specially made iron-silicon bronze cage is used to retain four balls at equally spaced positions. The flat face of the upper race is used to facilitate assembly of the apparatus and the number of balls is limited to four in order to achieve realistic contact stresses without using excessive dead weight loads.

The bottom of the desiccator is filled with glass marbles to reduce the volume of oil required and to provide added surface to nucleate gas bubbles when degassing the lubricant.

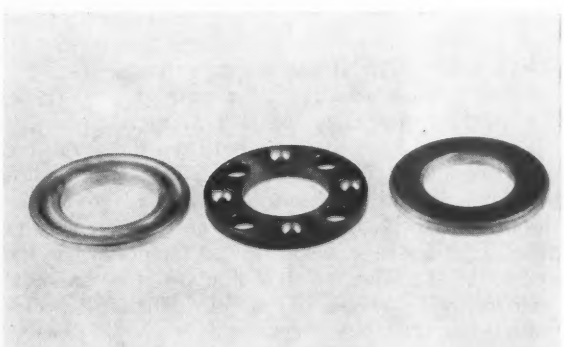


Fig. 3. Bearing Specimens for Controlled Atmosphere Apparatus Showing Lower Race, Cage and Balls, and Upper Race.

Experimental Method

The ball thrust bearings were operated in three different gaseous environments:

1. 92.5 per cent nitrogen—7.5 per cent hydrogen
2. Hydrogen
3. Helium

The following operating conditions were used:

Bearing load—40 lb (dead weight)
Ball-race contact stress—200,000 psi grooved race
290,000 psi flat race
Speed—3600 rpm
Ball surface speed—1500 fpm
Bearing temperature—200 to 220 F (lower race temperature)
Ball and race material—AISI 52100 steel
Ball retainer material—iron-silicon bronze

Three different lubricants, petroleum oil, polyalkaline glycol and MIL-L-7808 were investigated. The petroleum oil was an SAE 10 weight paraffine-base oil to which 3 per cent TCP was added. MIL-L-7808 is a diester turbine oil having a viscosity of about 3 centistokes at 210 F.

The procedure followed for evaluating the performance of the bearings was as follows. The bearing components were degreased in trichlorethylene, cleaned ultrasonically in a water-detergent mixture and weighed. The bearings were then mounted in the apparatus. Cotton gloves were used in handling the bearings. The desiccator was then filled with lubricant so that the bottom race of the test bearing was covered. The upper race was then mounted on the shaft and the upper mounting plate placed in position. Stop cock grease was used to insure sealing of the closure. The upper race was positioned over the lower race by sliding the mounting plate on the desiccator. When the shaft and upper race were positioned, the mounting plate was then clamped in place, all wire leads connected and a bell jar placed over the motor stator. The bell jar was used so that the system could be evacuated without collasping the can and bellows which seal the motor and shaft in the atmosphere chamber. The heater was then turned on and as soon as the bearing temperature stablized at 200 F a vacuum pump was attached to the outlet line and the desiccator and bell jar evacuated. The system was allowed to pump down until air bubbles stopped emanating from the oil and a vacuum of about 5 to 10 microns was achieved. The system was then filled with the gas under study at slightly more than atmospheric pressure. After evacuating and flushing several times, the desiccator was filled with a flowing atmosphere of gas and the bell jar was removed from the top of the mounting plate. The gas outlet pipe was attached to a mineral oil trap and was allowed to bubble through it slowly. In this way a positive pressure of about 2 psi above atmospheric was maintained in the desiccator. The dew point of the gas was measured periodically by sampling the outlet gas with a dew point apparatus. No attempt was made to measure the purity of the gas in the desiccator. High purity gas was obtained for these experiments and every precaution was taken to prevent its contamination. Further precautions were taken with the hydrogen gas by passing it through a Catalytic purifier. It is assumed that this procedure did not remove all of the adsorbed gases (oxygen, water vapor, etc.) on the bearing metal surfaces as well as the oxides normally present. However, if these films were destroyed or removed by attrition during operation of the bearing in the atmosphere, it is felt that they could not be renewed so long as the lubricant was completely degassed and the atmosphere chamber well purged.

After establishing the controlled gaseous atmosphere in the desiccator, the induction motor was turned on and the dead weight load applied to the bellows. The bearings were allowed to operate for a minimum of 200 hours. Periodic measurements of torque, bearing temperature and shaft speed were taken during a run. The bearing torque was measured by observing the deflection of a calibrated spring used to restrain the pivoted lower bearing race housing. Shaft speed and bearing cage speed were measured with a strobotac. Bearing temperature was measured by means of a thermocouple attached to the back of the lower race.

EXPERIMENTAL RESULTS

Nitrogen-Hydrogen Mixture

Bearings were operated in the 92.5 per cent N_2 — 7.5 per cent H_2 mixture using both polyalkylene glycol and SAE 10 petroleum oil with 3 per cent tricresylphosphate additive. The synthetic oil was included as a possible heat-resistant lubricant. Bearing operating temperature was 220 F. Early in these experiments it was found that bearings operating without oil in this environment failed very rapidly. Bearings with a meager oil supply (petroleum oil) operated with relatively high torque and considerable metal transfer between the bronze cage and balls and races occurred. When a polyalkylene glycol was used as a lubricant, bearings failed rapidly. Considerable galling and metal transfer occurred in the bearings during the runs with this lubricant. The use of this lubricant was abandoned early in the program and no further study was made of its performance.

Operation with the petroleum oil was completely satisfactory during a series of 200 hour runs. The oil did not show any tendency to decompose while operating in the gaseous environment and bearing operation was smooth. Bearings were run under identical conditions in a flowing air environment and, although the friction was slightly lower, the oil soon darkened and began to precipitate solid decomposition products.

The bearings operated in the N_2-H_2 atmosphere were bright and shiny after 200 hours operation. No weight loss could be detected. Microscopic examination revealed no signs of welding or seizure. The sliding areas of the cage positioning surfaces showed no galling and the ball pockets were bright and shiny where the balls had rubbed. The bearings operating in air were stained with oil decomposition products and oxides. To investigate the effect of prolonged operation in the gas environment some 1000 hour runs were made. Operation was satisfactory although the weight loss of the bearings was measurable. The total bearing weight loss was 15 mg. Bearings were also operated for 1000 hours in air for comparison but weight loss

measurements were meaningless because of a film of oxide and lubricant decomposition products which could not be cleaned off. Visual inspection of these bearings indicated little, if any wear, since the original lapping and grinding scratches were still visible.

Hydrogen

Ball-thrust bearings were operated in dry pure hydrogen in the atmosphere apparatus at 200 F bearing temperature. The lubricant used in these experiments was MIL-L-7808 synthetic oil. Bearings were also operated in air using the same lubricant for comparison purposes. During these runs it was found that the torque for flood lubricated bearings operating in hydrogen was about twice as high as for comparable runs in air. A total wear of a few milligrams in 200 hours continuous running was measured for bearings in hydrogen. Again, films and deposits which could not be cleaned off masked the wear measurements on comparable bearings operating in air.

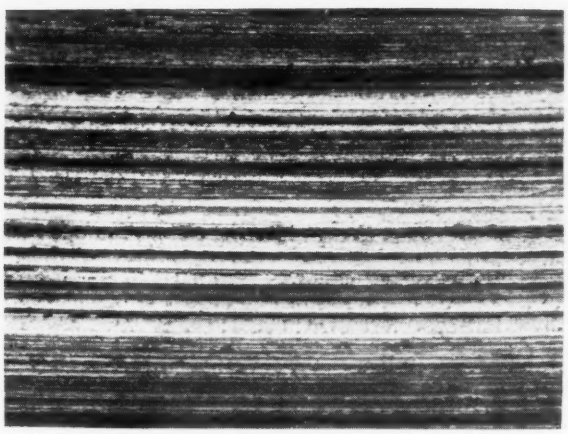


Fig. 4. Ball Path in Lower Race Groove after 200 Hour Operation in Air at 200 F Bearing Temperature Using MIL-L-7808 Lubriciant—100X.

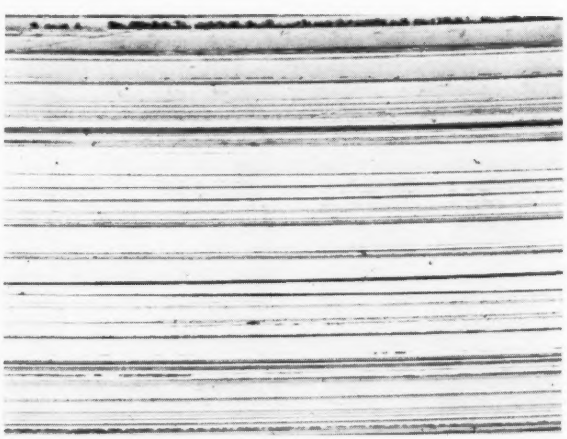


Fig. 5. Ball Path in Lower Race Groove after 200 Hour Operation in Pure Hydrogen at 200 F Bearing Temperature Using MIL-L-7808 Lubricant-100 X.

Fig. 6. Typical Area on Ball Surface after 200 Hour Operation in Air at 200 F Bearing Temperature Using MIL-L-7808 Lubricant-100 X.

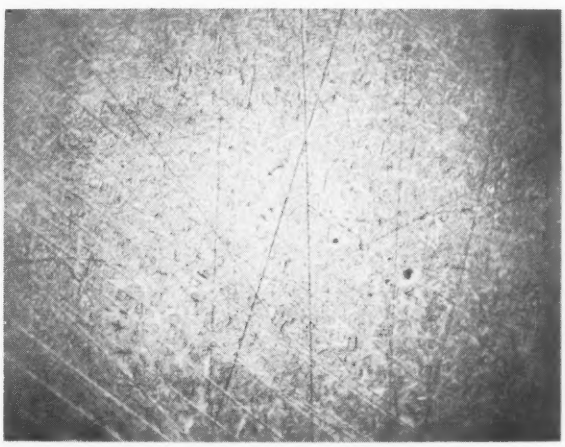


Fig. 7. Typical Area on Ball Surface after 200 Hour Operation in Pure Hydrogen at 200 F Bearing Temperature Using MIL-L-7808 Lubricant-100 X.

The appearance of the post-test bearings which had been run in hydrogen was striking. The balls and wear tracks in the races and cage pockets appeared highly polished. Under the microscope, these surfaces showed an almost perfect metallographic polish. Figs. 4 and 5 show the difference between the ball paths on the bottom races of the bearings run in air and those run in hydrogen. The balls shown in Figs. 6 and 7 show similar characteristics. Note the tarnish on the ball run in air and its complete absence on the ball run in hydrogen. Taper sections were made of the bearing races and are reproduced in Figs. 8 and 9. Note that the original grinding scratches from manufacturing are much more in evidence on the bearing run in air while they are all but obliterated from the bearing run in hydrogen.

Helium

Some limited experiments have been carried out using pure helium as a gaseous environment for ball bearings. Ball thrust bearings were operated in helium for 1000 hours using petroleum oil lubricant. Bearing temperatures were maintained at 200 F.

Fig. 8. Taper Section of Lower Race Groove after 200 Hour Operation in Air at 200 F. Bearing Temperature Using MIL-L-7808 Lubricant-100 X.

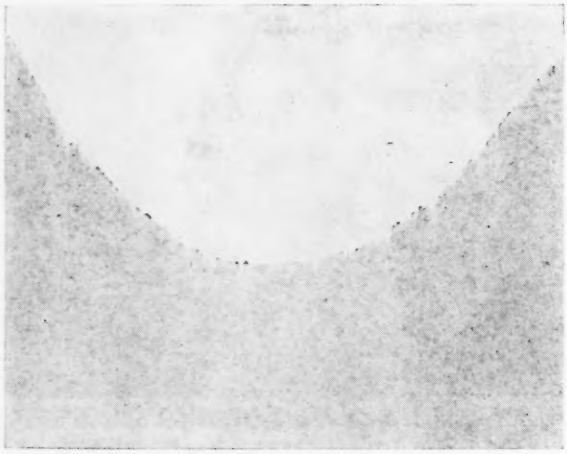


Fig. 9. Taper Section of Lower Race Groove after 200 Hour Operation in Dry Hydrogen at 200 F. Bearing Temperature Using MIL-L-7808 Lubricant-100 X.

Bearing operation in helium was smooth and satisfactory. Balls and ball paths were polished but not as highly polished as those bearings run in hydrogen. In general, operation in helium was similar to that in the nitrogen-hydrogen mixture.

CONCLUSIONS

Bearings operate well for the relatively short time running periods investigated (200 hours) in gaseous atmospheres free of oxygen and water vapor as long as they are well lubricated. For instance, oil mist lubrication might not be sufficient. Differences in performance of lubricated bearings in air and in pure gases are subtle and it is difficult to extrapolate these results to long periods of operation (10,000-50,000 hours). However, it is significant that ball bearings are now operating in the centrifugal compressor in an in-pile loop using the SAE 10 petroleum oil and after 2500 hours continuous running there is no sign of bearing distress.

The most obvious effect of gaseous environment on well lubricated bearings is the production of clean, polished bearing surfaces. Bearings operated in hydrogen were easily discernable by their characteristic high polish. No tendency for galling could be observed —even the cage locating surfaces which continuously rubbed on the lower race showing no galling.

Another effect which was unexpected in the hydrogen environment occurred when a bearing was inadvertently run under conditions of meager lubrication using MIL-L-7808 as the lubricant. The balls from this particular experiment came out looking as if they had been copper plated. It is possible that the ball surfaces were cleaned of native oxide films by the combination of rubbing and hydrogen reduction at the asperity contact points making it possible for the cage wear particles to adhere to the steel and be smeared over the surface in a continuous metallic film.

In conclusion, it should be pointed out that the experiments described represent only one small facet of the coming technical problems to be encountered in the operation of bearings in high purity gases or vacuums. There are many applications where bearings must be sealed in a closed system which will tolerate no contamination by conventional lubricants. In these systems, the problem of bearing seizure must be solved or the bearings mounted outboard and a frustrating sealing problem dealt with. High temperatures, in the neighborhood of 1000 F, will be encountered to compound the difficulties.

It is clearly evident that considerably more research is required in this field. The study of the effects of these various environments on rolling and sliding surfaces will not only lead the researcher to many interesting discoveries but will also, if rigorously pursued, uncover information on the fundamentals of wear and friction phenomena.

ACKNOWLEDGMENT

The author is indebted to C. M. Allen, Engineering Mechanics Division Consultant for his aid and advice and to Fred Zugaro, Technical Assistant, for his part in assembling and running the apparatus. This paper is based in part on work performed under AEC Contract W-7405 eng-92.

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Determination and Correlation of Fundamental Instrument Bearing Parameters

by Theodore P. Barnard and Richard S. Guyette
Miniature Precision Bearings, Inc.
Keene, New Hampshire

The purpose of this paper is three-fold:

1. To show why the measurement and evaluation of dimensional, geometrical and performance qualities of miniature instrument ball bearings requires the use of unique ultra-precise instruments.

2. To describe the instrumentation used to accomplish the required measurements and particularly the development of a bearing quality analyzer.

3. To illustrate by actual test results the use, correlation, and interpretation of these instruments and test data.

Instrument ball bearings, as the name implies, are used in highly sensitive and precise instruments, high speed spindles, and other applications requiring the ultimate in bearing perfection.

Miniature instrument ball bearings are those bearings with an outside diameter of 5/16″ or less. In actual practice, these range down to those as small as .0590″ outside diameter (Fig. 1). Their boundary dimensions and tolerances are generally to ABEC 5 or 7 standards. However, due to the nature of their major applications in missile and weapons instrument systems, critical tolerances are frequently held to standards ranging from 50 millionths of an inch to fractions of a millionth of an inch.

Ten years ago only one company in the United States manufactured miniature bearings. The entire market required only a few thousand a year. Today they are manufactured by the millions with eight or nine small, medium, and large companies competing vigorously in this field. This tremendous growth can be traced almost entirely to the increasing complexity of missile and aircraft guidance and weapons systems. As the complexity of these systems increases it becomes necessary to reduce the size and weight, in other words to miniaturize, the individual components in order to decrease the weight of the system to permit the missile or aircraft to carry a sufficient payload. Coupled with the greater complexity of the instrument systems and the attendant need for miniaturization is the additional requirement for greater system accuracy. Thus the miniature instrument bearing industry has been presented with two requirements; (a) it must continually reduce bearing size and (b) improve performance quality until it is equivalent to or better than standard size instrument bearings.

Five years ago existing measuring equipment was inadequate for use on miniature ball bearings because of lack of sensitivity and adaptability for tiny components. It was necessary to design new instrumentation of improved accuracy and versatility in order to develop and produce miniature instrument bearings of satisfactory quality. The object of this paper is to describe this equipment and how it has been, and will be, used to evaluate fundamental bearing parameters and their effect on performance.

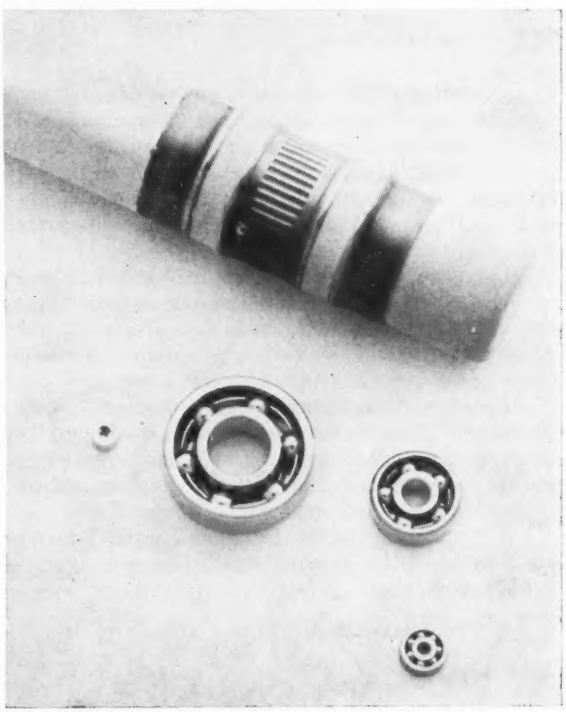

Fig. 1 Miniature Instrument Bearings

Presented before the 14th ASLE Annual Meeting, Buffalo, New York, April, 1959.

One fundamental bearing performance characteristic, torque, should theoretically reflect the degree of perfection of all bearing parameters. Thus an ideal torque tester should be able to evaluate these parameters both quantitatively and qualitatively. The Running Torque Tester (Fig. 2) is the result of four years of intensive research and development effort to fulfill this need. A description of this device, its operation, interpretation of torque charts, and correlation with other test data will be dwelt with at length in this paper. It is the cornerstone on which the other elements of this work depend.

Another basic but less understood performance characteristic is noise and vibration. Concurrently with the development of the torque analyzer, a vibration and noise testing device (Fig. 3) was also developed.

During this period a roundness comparator (Fig. 3) was introduced from England and has successfully solved the problem of evaluating fundamental bearing race geometry and geometrical relationships of various race surfaces.

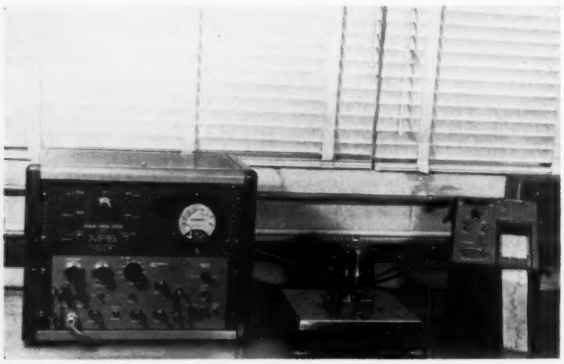

Fig. 2 Running Torque Tester

The ball could be suitability evaluated for dimensional accuracy by adapting existing equipment. It was necessary, however, to develop an instrument for evaluating ball surface finish. This paved the way for major advances in ball finish and provided another tool for the evaluation of the effect of ball surface finish on bearing performance.

Lately, a waviness meauring instrument (Fig. 3) has been adapted for use on miniature components for the measurement of low and high frequency race groove waviness. This device, is capable of distinguishing waviness to tenths of a micro-inch rms.

In the interest of brevity, descriptions of this supporting instrumentation are held to a minimum. The effect of the parameters measured on these instruments is dealt with during the interpretation and correlation of data contained in the torque charts.

The functions of the Running Torque Tester as an instrument for bearing quality analysis can be defined as follows:

1. The quantitative measure of bearing running torque under various conditions of speed, load and lubrication.
2. The qualitative measure of the effect of the basic bearing parameters.

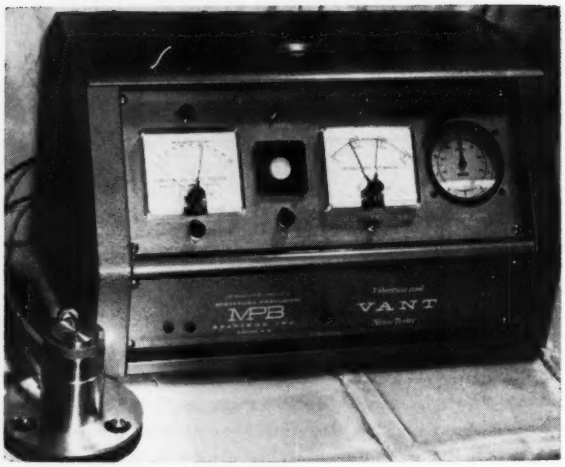

Fig. 3(a) Vibration and Noise Tester

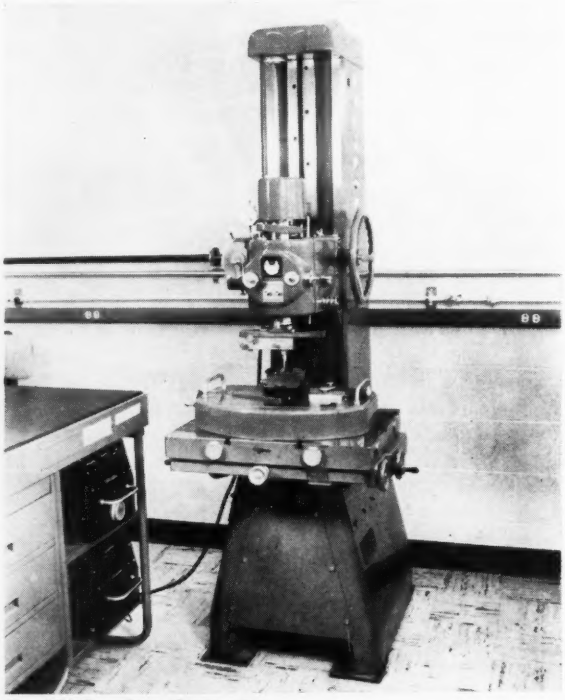

Fig. 3(b) Roundness Comparator

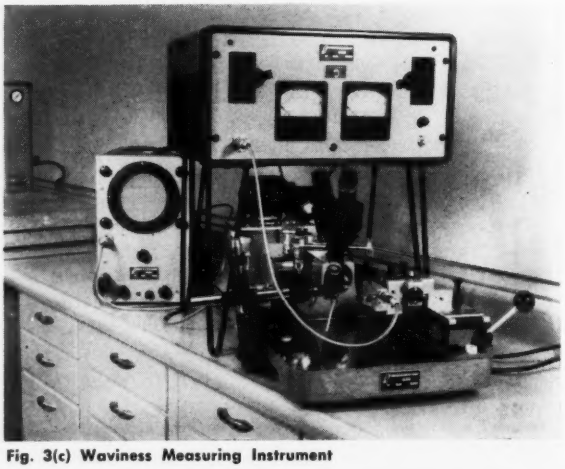

Fig. 3(c) Waviness Measuring Instrument

This Running Torque Tester's design allows precise performance of these two functions. A shaft is suspended vertically from the inner race of the bearing. A guide jewel at the bottom holds the shaft in alignment. The outer race of the bearing is supported in a massive housing which turns at a synchronous speed. The inner race tends to rotate the shaft due to the friction transmitted from the outer race through the balls to the inner race. The signal generator and torque motor rotors are attached to the shaft. As the inner race and shaft rotate slightly, the signal generator produces an electrical output power proportional to the shaft angular displacement which is fed to the amplifier and recorder. The amplifier provides power to the torque motor, through a servo loop, to restore the shaft to its null position. (1)

An air loading cell is also attached to the shaft. This is an aluminum cup to which external air pressure is applied. The axial load on the bearing can be varied by changing the air pressure, without affecting the instrument's frequency response and accuracy. The tester has a wide range of sensitivity settings. By means of an attenuation control the scale can be set anywhere in the range of 500 to 50,000 mg mm full scale chart deflection. The response of the system is flat to 20 cps which at a speed of 2 rpm allows the detection of torque producing defects separated by no more than one micro-inch.

The Running Torque Tester meets all the requirements of MIL Standard 206 and has greater sensitivity. Basically the torque trace is a graph of the instantaneous values of torque obtained for two revolutions of the outer race, one clockwise and one counter-clockwise, with a 75 gram axial load applied to the inner race. Normal rotation speed is 2 rpm. Reading from the bottom to the top of the trace (Fig. 4), there is a 360° revolution of the outer race in a clockwise direction, then a dwell when the rotor is stationary, followed by a 360° revolution of the outer race in a counter-clockwise direction. Each small mark at the right of the chart represents 15° rotation of the outer race. Each wide mark represents 90° of rotation. Each minor division on the chart can equal any value of torque from 10 to 1,000 mg mm depending on the attenuator setting and loop gain calibration. A value of 100 mg mm per minor division is standard.

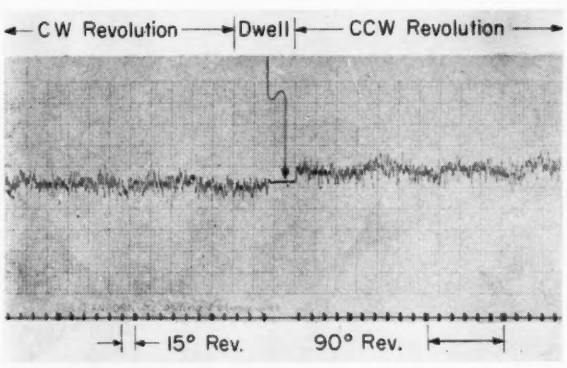

Fig. 4 Typical Torque Trace
1 Minor Division = 100 mg mm
1 Major Division = 500 mg mm

The trace can be analyzed for the following quantitative measures:

1. Average running torque.
2. Peak running torque.
3. Average peak running torque.
4. Average hash width.
5. Maximum hash width.
6. Amount of wander due to geometrical imperfections.
7. Torque variation due to retainer action.

Average running torque is the average of all torque values throughout the test cycle. Lines representing the average value of the trace on each side of the dwell position are drawn on the chart. Halfway between these two lines is the zero torque line of the chart for any particular bearing. The determination of these average lines can be accomplished by two means. First, by use of a polar planimeter, whereby the entire graph is traced and the average line calculated from the area of a rectangle being equal to its base times its height. An easier method is by the use of a transparent rule laid over the trace for determination by eye of the average value of the trace. Both methods have been used and the latter method has proven to be much faster and quite accurate.

One-half the number of chart divisions between the two average lines, times the value of each minor division in mg mm, is the average running torque value.

Peak running torque is the maximum instantaneous value of torque occurring in the test cycle. Having found the zero point of the chart, as above, the peak running torque is the number of divisions from the zero line to the maximum peak value obtained in the cycle times the value of each division in mg mm.

Average peak running torque is the average of the instantaneous peak values of torque occurring in the test cycle. The tedious but most accurate method of determining this property is by calculating the value of each instantaneous peak in the trace and finding the average. A faster and more efficient method is to draw a line passing through all the instantaneous peaks and estimating, with a transparent rule, the average peak line for each revolution. The average peak running torque is one-half the number of divisions between the two average peak lines, times the value of each minor division in mg mm.

Average hash width is that value of torque which is the average of all the instantaneous torque values in a test cycle. This can be visualized as a band of torque through the trace. The exact method of determining the average hash width is to find the numerical average of all the instantaneous torque values. However, this is a long and tedious process and it is more practical to estimate the average by a study of the torque trace.

Maximum hash width is that band of torque which would include all instantaneous torque values occurring in the torque trace. This is equal to the width of the largest spike.

The "wander" due to geometrical imperfections is the amount of waviness of the torque trace in a test cycle. The maximum geometrical wander can be cal-

culated by drawing a line through the trace representing the low frequency torque deviation and then measuring the largest deviation from a straight line.

Retainer hangup is the amount of "drift" of the torque trace due to retainer action. The amount of torque drift beyond a bearing's normal peak is a quantitative measure of hangup. (See Retainer Analysis Section).

Having described the Running Torque Tester and the interpretation of torque charts, discussion of the use of this and supporting instrumentation in the determination and correlation of fundamental bearing parameters follows:

A. Geometry Analysis:

The waviness of the torque trace is a function of bearing geometry. Ball groove roundness, ball groove to I. D. or O. D. concentricity of inner and outer race, groove to face run-out, and groove curvature all contribute to the bearing's ultimate torque performance. The degree to which each of these geometrical variables affects torque is currently being investigated.

Fig. 5 is a trace of a bearing with good geometrical properties. The average running torque of this bearing is 200 mg mm and the peak running torque 700 mg mm, with a maximum geometrical wander of 150 mg mm. Also shown in Fig. 5 are Talyrond charts of the outer and inner ball grooves of this bearing. These charts show the radial deviations of the ball grooves from a true circle, magnified 10,000 times with an accuracy of .000003 inch. Each minor division on the graph equals .000010 inch when the magnification is 10,000× and .000025 inch when it is 4,000×. The filter setting of 1-15 indicates that all radial deviations occurring 15 times or less in one circumference will be sense and recorded. The outer and inner ball grooves in Fig. 5 are .000017 inch and .000010 inch two point out-of-round respectively.

Fig. 6 is an example of a bearing with poor geometrical characteristics, namely an .000083 inch out-of-round outer ball groove. The average and peak running torques of this bearing are 250 mg mm and 950 mg mm respectively, with a maximum geometrical wander of 900 mg mm.

Bearing geometry characteristics are easily discernable qualitatively, without the aid of any of the measures described previously. A visual examination of the torque trace gives a clear, comparative picture of the degree of a bearing's geometrical perfection.

B. Retainer Analysis:

Retainer hangup, and its effect on torque performance, can also be determined but is often not easily distinguishable from geometry "wander." However, the majority of the time it can be recognized because it is a randomly occurring defect, whereas, geometrical "wander" is more or less sinusoidally repetitive.

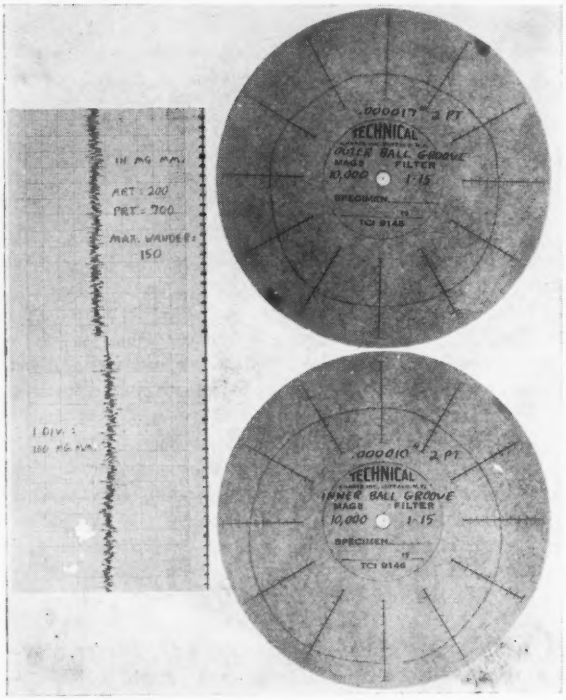

Fig. 5 Good Geometry Example
ART = Average running Torque
PRT = Peak running Torque

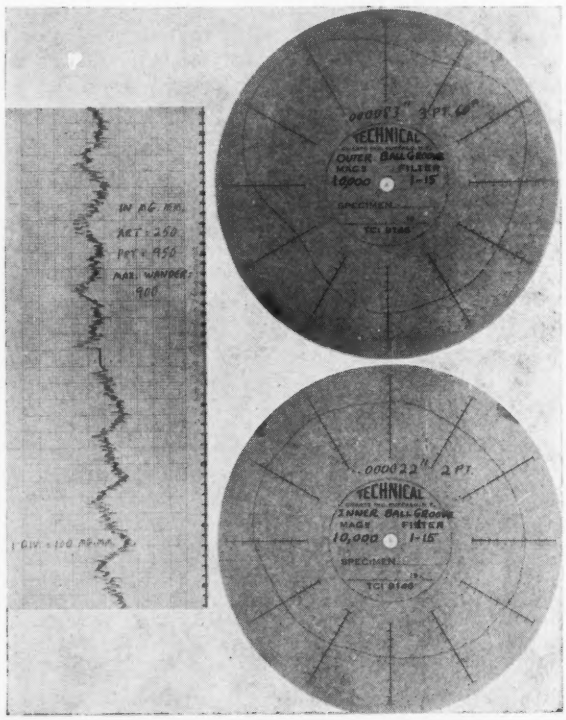

Fig. 6 Poor Geometry Example

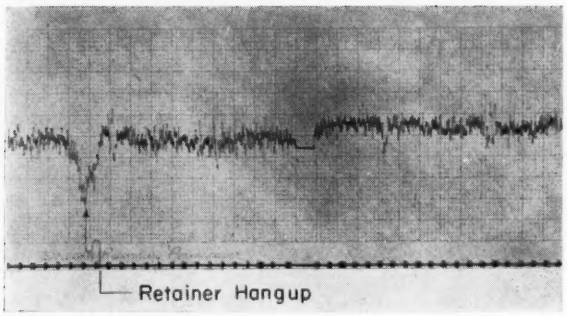

Fig. 7 Retainer Hangup Example
1 Major Division = 100 mg mm
Average Running Torque = 200 mg mm
Peak Running Torque = 1650 mg mm

Fig. 7 illustrates a typical retainer hangup. In Fig. 7 the hangup occurs in only the clockwise revolution. If this were a geometrical defect it would be seen also in the counterclockwise revolution and would occur more than once in each direction. The bearing whose trace appears in Fig. 7 has an average running torque of 200 mg mm and a peak running torque of 1650 mg mm. The retainer hangup contributes 650 mg mm of the 1650 mg mm peak.

C. Surface Finish Analysis:

The torque trace provides excellent qualitative surface finish analysis of the combined surface finish characteristics of ball grooves, balls, and separators as well as randomly occurring defects. Before presenting examples of surface finish analysis, other instrumentation and terminology must be more clearly defined as follows:

1. Instrument for the measurement of ball groove waviness—A low band meter indicates the rms height of irregularities occurring 3.5 to 17 times in one circumference and a high band meter shows the rms height of irregularities occurring 17 to 300 times per circumference. (2)
2. Vibration and Noise Tester—This instrument measures the axial vibration velocity in microns per second of the inner ring with the outer ring rotating at various speeds. The rotational speed used for all data in this paper is 600 rpm.
3. Ball Surface Quality—this is measured with a comparator type instrument which gives a qualitative measure of ball surface finish quality in terms of torque. Grade L is representative of the best quality ball surface finish and is equal to .25 micro-inches rms.

The four torque traces in Figs. 8 and 9 illustrate examples of surface finish analysis and the correlation of the torque data with that obtained from the supporting instrumentation. The four charts and the corresponding data demonstrate the following:

1. Effect on torque of overall excellent surface finish. (left, Fig. 8).
2. Effect of poor outer groove finish. (right, Fig. 8).
3. Effect of poor inner groove finish. (left, Fig. 9).
4. Effect of poor ball finish. (right, Fig. 9).

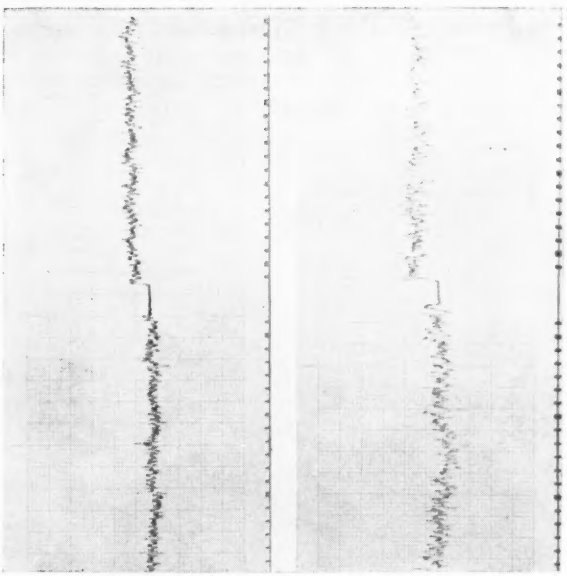

Fig. 8 Surface Finish Analysis

Left		*Right*
125 mg mm	Average Hash Width	350 mg mm
550 mg mm	Maximum Hash Width	1050 mg mm
0.4μ " rms	High Band-inner	0.4μ " rms
0.5μ " rms	High Band-outer	1.0μ " rms
Grade L	Ball Surface Quality	Grade L
15	Vibration and noise tester level	26

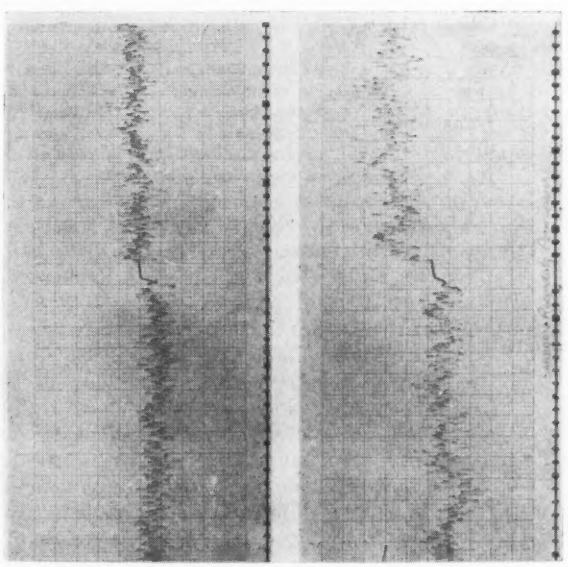

Fig. 9 Surface Finish Analysis

Left		*Right*
450 mg mm	Average Hash Width	500 mg mm
1200 mg mm	Maximum Hash Width	1550 mg mm
1.2μ " rms	High Band-inner	0.6μ " rms
0.6μ " rms	High Band-outer	0.6μ " rms
Grade L	Ball Surface Quality	4 × Grade L
30	Vibration and Noise tester level	45

Beneath each trace is waviness gage and ball gage data showing the changes in the surface finish. Also listed is the vibration and noise level of performance in microns per second. These four examples are typical and were selected from a large amount of data collected during this program.

Random defects, such as pits, scratches, comet tails, and brinell marks occur as random spikes on the torque trace. The left trace in Fig. 10 is of a bearing with a large comet tail in the ball path on the inner groove. There are three major peaks per revolution, each of a different magnitude.

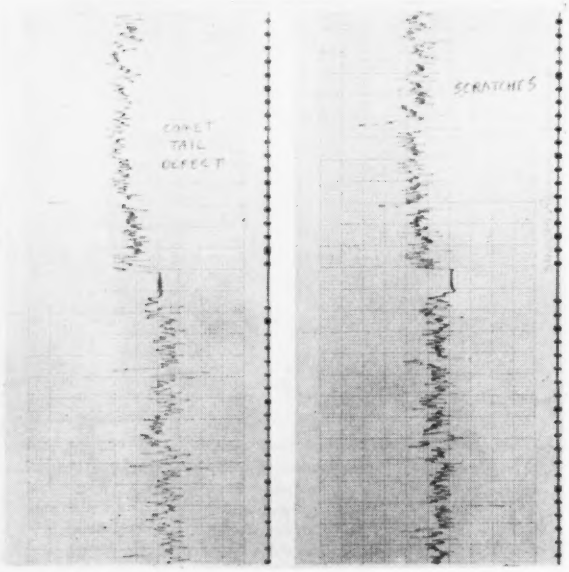

Fig. 10 Random Defect Analysis

Left		*Right*
400 mg mm	Average Hash Width	450 mg mm
3400 mg mm	Maximum Hash Width	2850 mg mm
0.7μ" rms	High Band-inner	0.7μ" rms
0.6μ" rms	High Band-outer	0.7μ" rms
Grade L	Ball Surface Quality	Grade L
38	Vibration and noise tester level	40

The trace on the right of Fig. 10 represents a bearing with several scratches across the ball grooves. Occurrence of the peaks is haphazard and each is of different magnitude. The values of the surface finish parameters as measured by the waviness gage and ball gage are given as well as the vibration and noise levels of performance. Note that the waviness readings and noise levels of these random defect bearings are similar to those with overall poor surface finish whereas the torque traces are distinctly different. Brinell defects are seen as fairly regularly occurring spikes of greater width than most random defects (Fig. 11). They are also distinguishable by the occurrence of 2 or 3 spikes within 30° rotation, repeating a number of times in a 360° revolution depending upon the number of balls in the bearing. Also in Fig. 11 are traces of the inner and outer ball grooves showing six brinell marks per groove. The running torque trace indicates that the balls roll over these marks four times per revolution of the outer race. This type of analysis is used to evaluate the relationship of defects of known magnitude and configuration with torque.

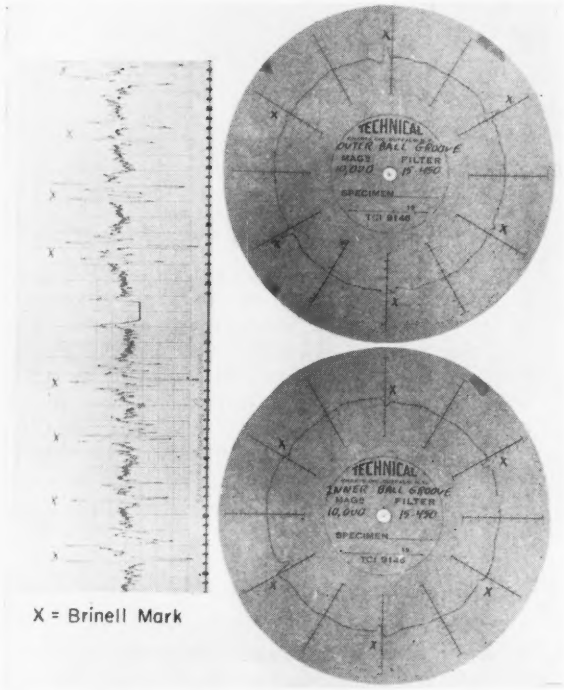

Fig. 11 Brinelling Example

The normal chart speed is 2.5 mm per second. By increasing this speed, the torque trace may be spread for a more detailed picture of the individual torque spikes. Fig. 12 shows a trace of a bearing with good surface finish on the left and then a portion of the same trace on the right with the paper speed increased to 12.5 mm per second.

The average and maximum hash widths on the trace do not need to be determined for the instrument to be of value. A visual examination of the trace will show the quality of a bearing's surface finish without resorting to any calculations once experience has been gained. The tester can distinguish between overall poor surface finish and random defects whereas the waviness gage and the vibration noise tester, as seen in the above examples, cannot. This is because the Running Torque Tester is a peaking device and presents a qualitative picture of bearing defects as well as a quantitative one.

D. Dirt Analysis:

The evaluation of bearing cleanliness and cleaning procedures is a simple matter. Fig. 13 shows a dirt-contaminated bearing on the left and, on the right, the same bearing after washing. In Fig. 13 the maximum hash width

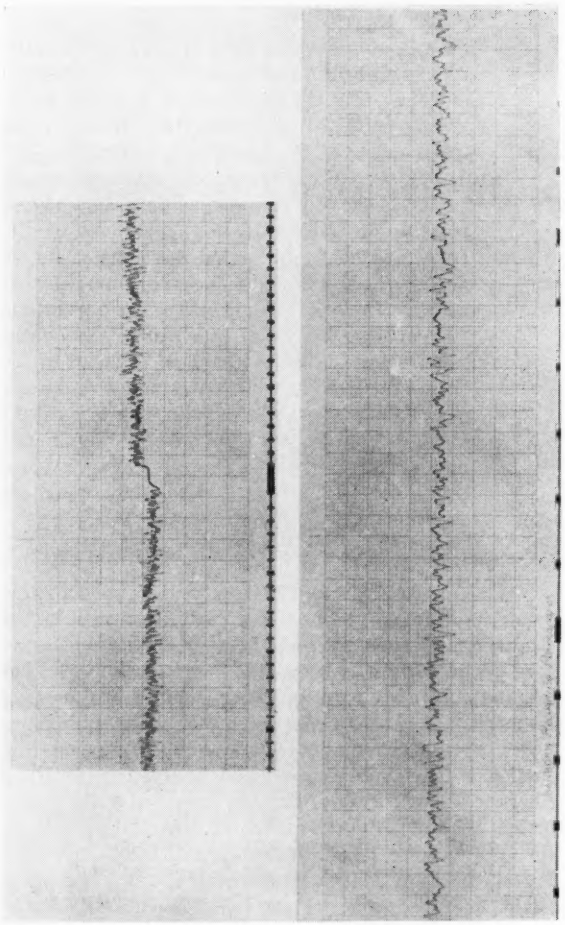

Fig. 12 Spreading of Instantaneous Torque Values
***Right* (increased paper speed to allow better study of surface finish defects)**

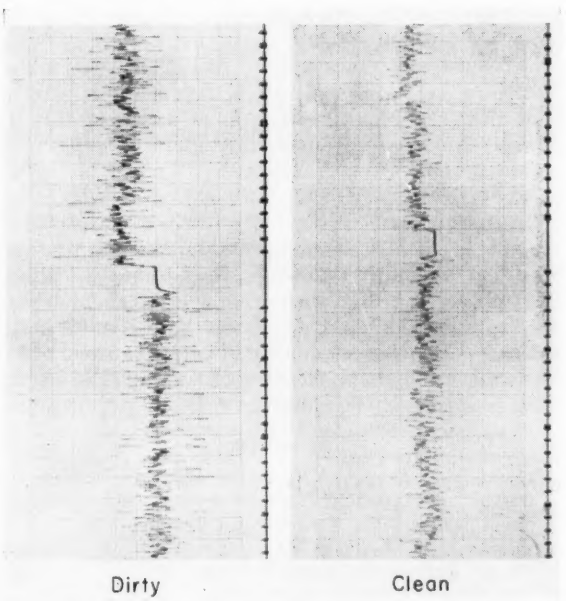

Fig. 13 Dirt analysis
***Left*—Maximum Hash Width = 4000 mg mm**
***Right*—Maximum Hash Width = 1600 mg mm**

was reduced from 4000 to 1600 mg mm by washing.

Peak torque due to dirt can usually be distinguished from random surface finish defects by the thin "spikes" which they make on the torque traces. However, this is not always the case as a larger piece of dirt may very well contribute to a wide instantaneous value of torque. In order to accurately determine dirt contamination a bearing must be thoroughly cleaned and then retested.

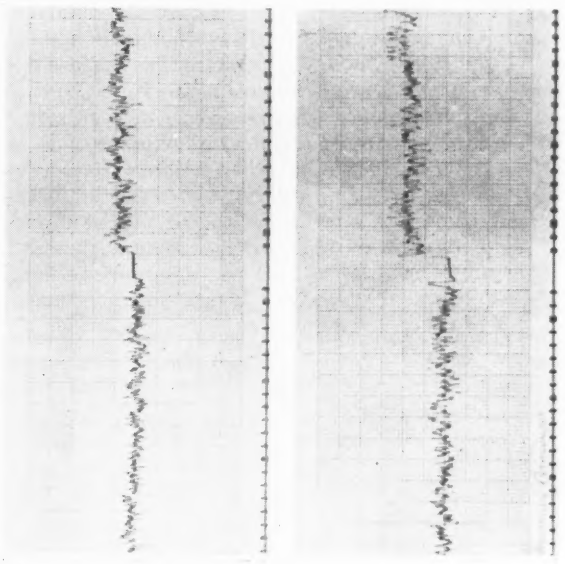

Fig. 14 Lubrication Analysis

Left		*Right*
200 mg mm	Average Running Torque	450 mg mm
850 mg mm	Peak Running Torque	1150 mg mm

E. Lubrication Analysis:

A lubricant's contribution to bearing torque can be evaluated. Standard bearing lubricants will usually cause a large torque shift, increasing the average and peak torque values by an amount dependent on the lubricant's viscosity and the rotational speed of the bearing.

Fig. 14 is an example of a bearing before and after lubrication with a standard instrument bearing lubricant. The larger torque value after lubrication is easily discernible. The average running torque increased by 250 mg mm and the peak running torque by 300 mg mm.

Lubrication cleanliness can also be evaluated. This evaluation would be identical to that discussed in the previous section of contaminated vs. clean bearings. A lubricated bearing when torque tested may show dirt spikes on the trace. If, after washing the bearing, the dirt spikes disappear, then the lubricant was contaminated as indicated by the torque trace spikes. (3)

F. Load vs. Torque:

Inertia-free axial loads up to 15 pounds can be applied with this tester. Fig. 15 shows load vs. torque traces on one bearing with the following axial loads in grams: 75, 200, 400, 600, and 800. On each chart one minor division equals 250 mg mm. The average running torque increased from 510 mg mm at 75 grams load to 3060 mg mm at 800 grams load. The peak running torque increased over the same load range from 1275 mg mm to 5350 mg mm.

All the charts in Fig. 15 were taken so that one minor division equals 250 mg mm in order to show qualitatively the torque increase due to load. During a quantitative evaluation each chart would be run at a sensitivity such that the instantaneous torque values would be readily discernible. This qualitative picture in Fig. 15 shows the large increase in torque shift with increase in load as well as the increase in average and maximum hash width. The increase in hash width, or surface finish effect, is somewhat unexpected and merits further investigation.

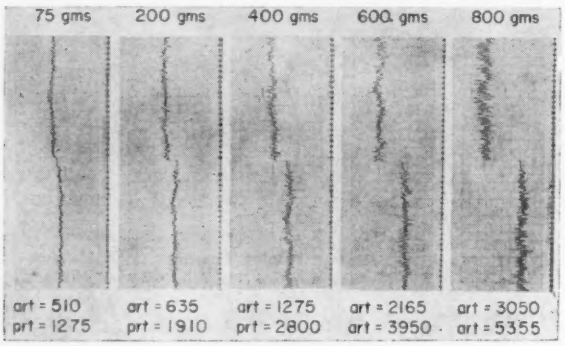

Fig. 15 Load Vs. Torque Analysis
art = average running torque
prt = peak running torque

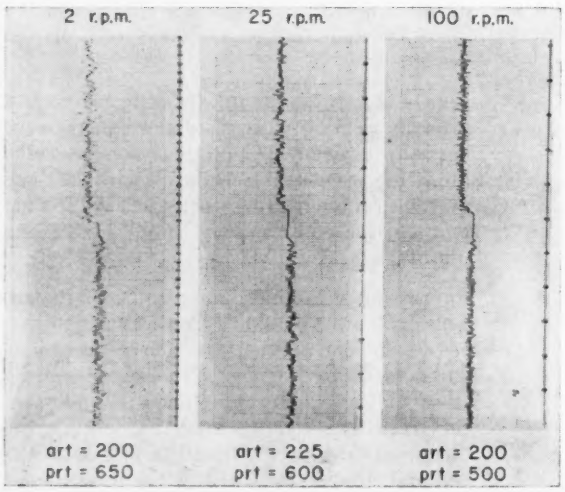

Fig. 16 Speed vs. Torque Analysis

G. Speed vs. Torque:

Speeds of the outer race from 2 rpm to 100 rpm can be obtained on this tester at the present time. Fig. 16 illustrates a bearing run at speeds of 2, 25, and 100 rpm. Whereas the trace taken at 2 rpm shows a complete 360 degree revolution in each direction, the traces for 25 and 100 rpm show only 90 degrees rotation in each direction. The rest of the trace has been eliminated for clarity. There are two distinctive torque characteristics at speeds above 2 rpm: (a) the instantaneous values of torque occur much more frequently requiring a faster paper speed in order to see them and (b) the values of average and peak hash width appear to remain fairly constant at speeds up to 100 rpm, with no significant increase or decrease in torque levels. Again, this is an unanticipated result which warrants additional investigation.

Conclusion:

The instruments and test work described in this paper have made possible large improvements in the quality and performance of miniature instrument bearings in the last few years. This, however, is just a beginning. There are many areas of fundamental bearing research that can be undertaken with such equipment. Much work still remains to be done in firming up and further exploring the correlation between geometrical tolerances, perfection of surface finish, and variations in materials with performance characteristics such as torque and noise. Much of the work already done must be repeated for higher temperatures, new lubricants, new materials, and strange environments. The phenomenon of bearing degradation is still another vital area that lends itself to study and evaluation with this instrumentation.

Further, a new standard of reliability, particularly in missile systems, is now necessary. Reliability on the order of 99.999% is the target for missile systems which must sometimes operate, continuously or intermittently, in a constant state of readiness for periods of three to five years. Those familiar with typical B-10 bearing life curves can readily appreciate the vast strides in reliability, perhaps greater than any achieved in the entire history of the ball bearing industry, that will have to come very rapidly if this requirement is to be achieved. This fundamental equipment, perhaps modified or slightly refined, is ready to be used in the next phase. It is our purpose to solve such problems by exploring the effect and interrelationship of basic bearing parameters on quality of performance in order to better understand their significance and to apply new knowledge to the development of better bearings.

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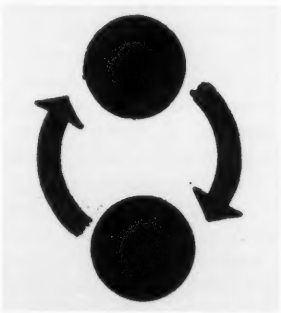
Progress in Roller Bearing Lubrication

by O. J. Horger,
Timken Roller Bearing Co.,
Canton, Ohio



Results of laboratory and field service tests are presented to show the progress being made toward operation of freight car journal roller bearings over a four-year lubrication period without adding grease. This period is important because it coincides with the recently extended rule for air brake cleaning.

Inactive freight cars present a bearing corrosion problem. Outdoor storage tests are described and field results outlined from six-month storage of ore cars each year over a five-year period. CRC tests of eight AAR approved greases show no rusting for three grease products, incipient rusting for three greases and severe rusting for two greases.

Advantages of phosphate coating the roller bearing for corrosion protection are presented with the aid of micrographs of the surface structure. The features of an adequate seal design for grease retention and excluding water and foreign matter are submitted based on successful performance of 400,000 seals over a 10-year period.

Some promising results were found in correlating electron optical studies with those made in a simulated service roller bearing journal box test used for qualifying grease.

The favorable economic value of roller bearing journals (1) is largely due to their dependable and maintenance-free operation. For some time now we have been able to operate passenger equipment cars and diesel locomotives between wheel turning periods before grease relubrication is necessary. This experience background has formed a logical basis for meeting the challenge of operating freight cars four years before grease relubrication is necessary. This period coincides with the recently extended rule for air brake valve cleaning from three to four years. At this time the car will be placed on the repair track for air brake work and the roller bearing journals may be lubricated in the most efficient and economic manner. In the case of high mileage cars, such as piggyback cars, wheel turning or wheel renewal may develop before four years has elapsed and roller bearing lubrication may be done at this wheel work period.

To meet this extended lubrication period means that the leakage of grease from the roller bearing must be very small. The wasteful practice acceptable for plain bearings of continuously adding lubricant only to have it leak out onto the wheel plate and down onto the rail head cannot be tolerated. This leads to (a) slipping of driving wheels so as to reduce locomotive tractive effort accompanied by excessive rail and wheel wear plus increased maintenance costs of electric drive equipment and (b) any defects on wheel plates cannot be detected because they are encrusted with a layer of road dirt and lubricant.

Realization of the four-year lubrication period is already here. By the time this paper is presented a Western railroad will have completed a four-year AAR test on a group of piggyback cars. The axle journals on these cars are equipped with sealed tapered roller bearing assemblies which have not had grease added for four years. Each of the cars inspected will have about 288,000 miles service on the initial charge of grease. In addition three other railroads have satisfactorily completed AAR tests on groups of freight cars in service without relubrication over a three-year period.

Lubrication of this type of sealed roller bearing assembly over an extended period presented a number of engineering problems requiring solution before 22,500 car sets of this bearing assembly could be placed in road service over the past five years. The laboratory research and testing related to lubrication along with findings from road service will be discussed.

Presented before the 14th ASLE Annual Meeting, Buffalo, New York, April, 1959.

INACTIVE CARS

Bearings are subjected to corrosive environment when held in the storehouse, mounted on wheel and axle assemblies maintained as spares, or on idle cars not in service operation. Some years ago when oil was used as a lubricant instead of grease it was believed necessary to periodically move idle cars or rotate the bearing several times. It was reasoned that this procedure would replace the protective oil coating which had gradually drained off the bearing. Such practice was discontinued when the lubricant was changed from oil to grease. It is not necessary to move cars or rotate bearings to prevent rusting of roller bearing journals or for any other reasons associated with the use of roller bearings.

A test shown in Fig. 1 has been continued since 1949 to explore the two factors of corrosion and brinelling of journal roller bearings* on idle equipment.

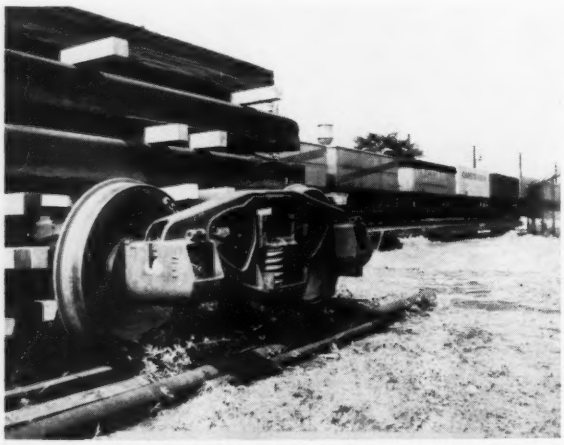


Fig. 1. Stationary truck located along main line for test of brinelling and corrosion of journal roller bearings.

Fig. 2. 90-ton ore cars embedded in snow during winter storage.

* The journal bearings may be identified under AAR Specification D-39-1957 For Approved Journal Roller Bearings Applicable to Interchange Freight Cars and as furnished under AAR Approval Certificate No. 1 by the Author's Company as an AP (All-Purpose) type bearing.

Here a 5-½ × 10 inch freight car truck is located on a track adjacent to 1% grade on the main line of a railroad through Canton, Ohio and loaded on the center plate with steel billets. Vibrations from passing trains are transmitted to the journal roller bearings. The four journal bearings have been lubricated with different oils and greases during the ten-year test duration. All the oils used and some of the grease lubricants approved under the now obsolete AAR Specification M-917-53 permitted mild degrees of corrosion to form but no brinelling of bearings has been detected. These tests are being continued using grease products to the later AAR Specification M-917-56 but it is too early to report results here.

One example of corrosion-free bearings taken from service performance is being cited for the severe car storage conditions shown in Figs. 2 and 3. These photographs illustrate the snow banks formed around the car bodies and journal bearings on some 3000 95-ton ore cars stored each season on the largest Canadian ore-hauling railroad. These cars are not moved while they are in storage for about six months of the year; after the snow melts around these cars in the spring they are placed in road service without relubrication or any attention to the journal bearings. No bearing corrosion has been found after five seasons of storage and average mileage per operating season

Fig. 3. Snow shoveled away from journal roller bearing on ore cars to illustrate storage conditions.

of 31,000 miles per car. The present schedule is to add grease to these bearings only at wheel turning or wheel renewal periods.

There has been only one overheated bearing in five years service with an accumulated 396 million car miles. This performance record is a good recommendation for grease lubrication of roller bearings under difficult conditions. These cars operate in 10,000-ton 125 car trains in continuous running over a 355-mile distance in 15 hours from the mines to the docks with only one scheduled stop for a crew change. Train arrival is timed so that the cars operate over rotary dumpers into waiting boats; any train delay means expensive boat delays.

RUST INHIBITOR IN GREASE

Additional measures have been taken to resist bearing corrosion in that various grease products now incorporate a rust inhibitor. AAR Specification M-917-56 for journal roller bearing grease specifies that the grease contain a "suitable rust inhibitor" but no standard laboratory tests have yet been adopted to evaluate the effectiveness of rust inhibitors. ASTM Committee D-2, Subcommittee G, Sect. III-6 is studying the static corrosion test L-41 devised by the Coordinating Research Council (CRC) and used by the Armed Services for evaluating such characteristics (2, 3).

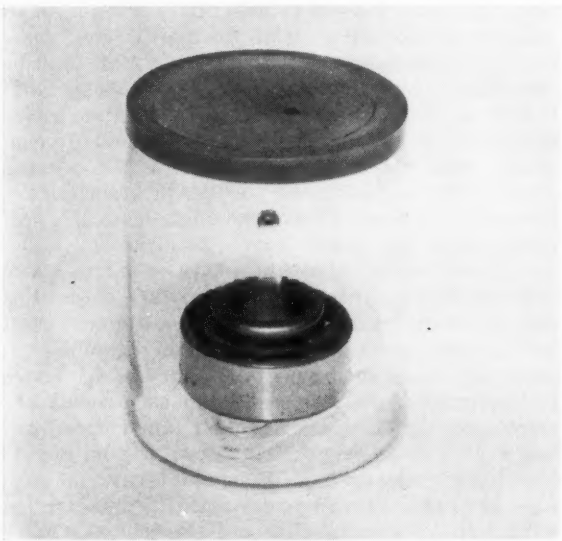


Fig. 4. Bearing stored in capped glass jar containing water.

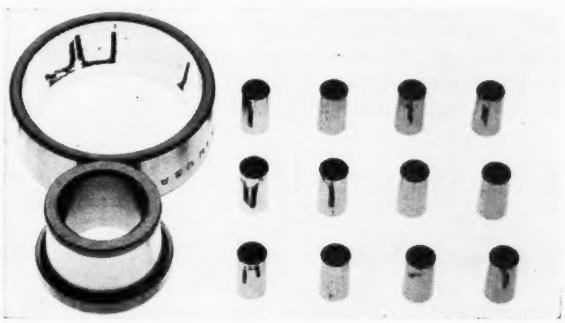


Fig. 5. CRC rating of 1 using grease C.

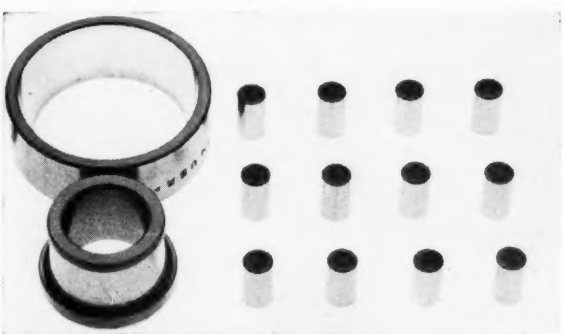


Fig. 6. CRC rating of 2 using grease D.

We have employed this tentative CRC test to six of the seven AAR presently qualified grease products from production batches. A bearing is used as a test specimen and a brief statement of the test procedure used here is: (a) bearing chemically cleaned, (b) 2 grams of grease distributed over bearing surfaces by rotating at 1750 rpm for 1 minute under 6 lbs. load, (c) bearing dipped in freshly boiled distilled water which had been cooled to room temperature, and (d) bearing supported on a glass rod so as to stand out of the 5 cc distilled water in a glass jar (Fig. 4) to which a lid is firmly fastened and the jar stored at 80 F temperature. At the end of 14 days the bearing is examined and rated, using one for no rust, two for incipient rust, and three for severe rust. The ratings found for these six greases are given in Table 1. For better statistical results three bearings were tested in this manner with each grease. Photographs typical of the findings for these three ratings are shown in Figs. 5, 6, and 7 for bearings not phosphate coated.

TABLE 1—RESULTS OF CRC TESTS ON EIGHT GREASES

GREASE	CRC RATING	SOAP TYPE	AAR SPEC.
A	1	Li	M-917-56
B	2+	Li	M-917-56
C	1	Li	M-917-56
D	2	Li	M-917-56
E	3	Li	M-917-56
F	1+	Ca-Li	M-917-56
G	3	Na-Ca	M-917-53
H	2	NA	M-917-53

This tentative test is being explored by many laboratories in order to control the factors influencing rusting and improve the reliability of this test before it is finally adopted as a standard procedure. It has been disturbing to find (a) only three of these six AAR approved greases have a one rating and (b) in some cases one production batch of a particular grease may for example give a one rating whereas another production batch of the same manufacturer's grease may give a two or three rating. This would indicate a need for quality control in grease manufacture.

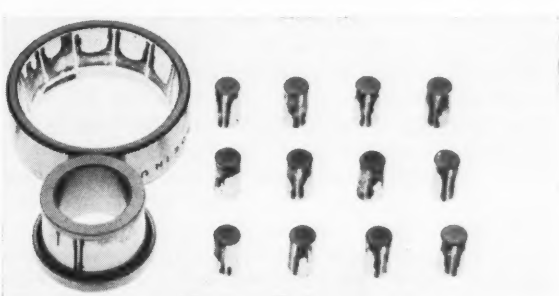


Fig. 7. CRC rating of 3 using grease E.

It is interesting to note that greases A through E (Table 1) are lithium base greases while F is a calcium-lithium mixed base grease. For comparison purposes CRC tests were also made on two greases to earlier AAR Specification M-917-53. One of the greases was a sodium-calcium mixed base product with a CRC rating of three and another was a sodium base with a rating of two.

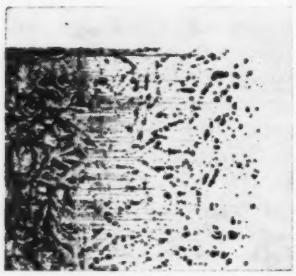


Fig. 8. Phosphate coated cone roller track at X100
Left—as-phosphated condition
Right—coating after polishing to simulate surface after being in service.

Fig. 9. Phosphate coated cone roller track X500 after 80,000 miles at twice rated journal load.

PHOSPHATE COATING

As a further means of resisting corrosion the various bearing and journal assembly parts are phosphate coated. This is accomplished by giving the finished metal parts a bath in a zinc-phosphate solution. A chemical reaction between this solution and the steel develops a phosphate coating firmly intergrown with the metal surface. Such a surface has a high absorptive capacity for lubricants to provide increased protection against corrosion. The type of surface obtained on a bearing cone is shown on the left hand side of Fig. 8. A network of microscopic channels and molehills are etched on the surface having a depth of the order of about 0.0005 inch. The right hand portion of this photomicrograph was obtained by polishing off the surface which has been found to simulate the condition after the bearing has been in service. To substantiate this statement Fig. 9 shows the cone surface of a 6 × 11 inch bearing after testing in the laboratory at 50,000 lbs. journal load (twice AAR static load) for the equivalent of 80,000 miles. The tops of the molehills containing the phosphate crystals are worn off in service operation leaving the bottom of the channels to help spread lubricant over the surface for rust protection.

This phosphate coating also has a secondary function to prevent galling and seizure between the contact surfaces of the cup and adapter. It is desirable to have the cup creep in the adapter; it increases bearing life because a different roller path surface is periodically presented for carrying the load through the rollers. End impact on the car facilitates this creeping action.

GREASE RETENTION

Proper charge of grease is about 40% of the total internal capacity of this sealed type bearing assembly. This amount is less than one pound for all journal sizes except the 6-½ × 12 inch and 7 × 14 inch. In order to provide adequate lubrication for four years service, leakage past the front and rear seals must be reduced to a minimum. A rubbing type of seal rather than a labyrinth seal must be used to retain a zero consistency grease and exclude water and other foreign matter from the bearing for the life of one-wear wheels. This performance is in line with AAR roller bearing specification D-39-1957 which requires a seal design life of nine years.

A seal which meets the above requirements is shown in Fig. 10. There are about 400,000 seals of this general design in service. The longest actual road service experience is over nine years on a group of ten stock cars where the original seals are still in service and none have been replaced. No mileage records are maintained on such cars. However, another railroad has a fleet of piggyback cars where the mileage is known and varies up to 380,000 miles. There is a large number of cars owned by various railroads where the mileage is between 150,000 and 300,000 miles. Our records show that seal defect replacements on all 400,000 seals in service are less than 1/100 of 1% between wheel work periods.

The cost of the seal assembly shown in Fig. 10 is greater than that used on other similar bearings assemblies but its performance record justifies its use.

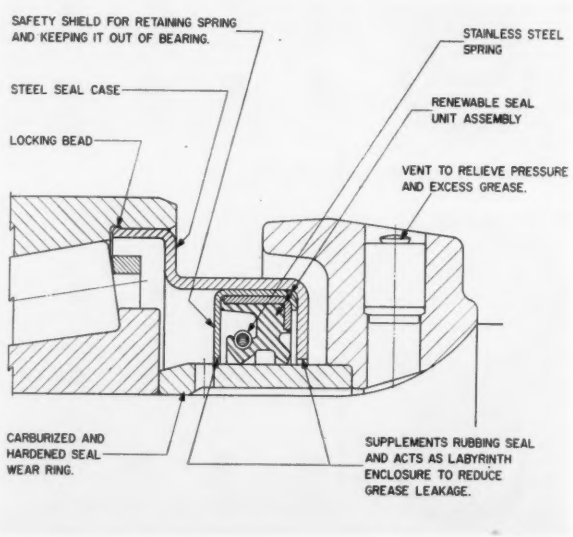

SAFETY SHIELD FOR RETAINING SPRING AND KEEPING IT OUT OF BEARING.
STAINLESS STEEL SPRING
STEEL SEAL CASE
RENEWABLE SEAL UNIT ASSEMBLY
LOCKING BEAD
VENT TO RELIEVE PRESSURE AND EXCESS GREASE.
CARBURIZED AND HARDENED SEAL WEAR RING.
SUPPLEMENTS RUBBING SEAL AND ACTS AS LABYRINTH ENCLOSURE TO REDUCE GREASE LEAKAGE.

Fig. 10. Bearing lubricant sealing arrangement.

Some of the important characteristics are:

(a) A metal bead on the seal case has never allowed a seal to work out of the bearing cup and no leakage occurs where it is press-fitted into the cup.

(b) Sealing lips run on a carburized and hardened steel sleeve of about the same hardness and metallurgical structure as the bearing. The hardness and structural characteristics of castings and engineering steels do not have adequate resistance to grooving developed by the lips of the rubber type seal rubbing on steel.

(c) The metal stamping and seal case form a labyrinth type seal to supplement the rubbing seal. A close running clearance is provided between the stampings and the wear sleeve. This labyrinth action may be considered as a safety factor in case of loss of retention quality of a rubbing seal; this labyrinth by itself insures satisfactory bearing operation for an extended period of time.

(d) The metal stamping adjacent to the stainless steel spring prevents the spring from dislodging from its normal location in the groove either during assembly or in operation. Also in case of spring breakage the stamping prevents the spring from entering the bearing and causing damage.

(e) The wear sleeve is ground by plunge feeding the grinding wheel to give circular rather than spiral grinding marks. Any lateral motion of the grinding wheel leaves a spiral thread finish tending to feed the lubricant either as a loss past the seal or toward the bearing.

(f) When seal replacement is necessary it is only required to replace the moulded seal element assembly and not the seal case. The seal case is designed from heavy gage steel stamping to last the life of the bearing.

(g) Venting action is obtained by a separate vent fitting and not through the seal which may interfere with its retention action.

(h) The steel wear sleeve is phosphate coated to allow microscopic feeding of the lubricant to the sealing lips. Thereby no detrimental wear occurs at these rubbing surfaces.

(i) Metal stampings surround the entire moulded sealing element to protect (a) the rubber from flying stones or debris from the roadbed; (b) sealing lips from damage in shop handling; (c) seal blowing out.

Merely purchasing a seal similar to Fig. 10 as made by numerous manufacturers can only result in costly road service difficulties. It is necessary to laboratory test not only each manufacturer's type of seal before qualifying his product for purchase but to (a) test each journal size seal design for 4-¼ × 8 inch through 7 × 14 inch bearing because a satisfactory seal for one size journal does not necessarily imply that a similar design and material seal for other axle sizes will also be satisfactory and (b) run sample lot tests from each production shipment for quality control. Dimensional characteristics of the seal are important but no more so than the compounding of the rubber and its heating cycle. This seal program is continuing to require considerable research and testing. Fig. 11 shows a battery of ten journals of fourteen available for evaluating various sealing arrangements and different greases long before they are placed in service. Water cooled rings surround the bearing to limit the internal bearing temperature to 160 F. The flow of water is automatically controlled by thermostat-operated valves.

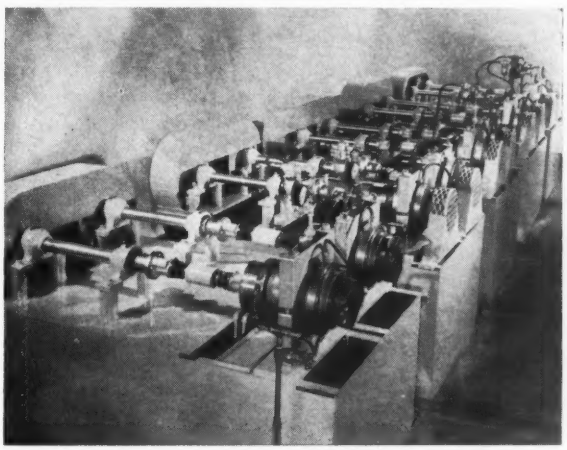


Fig. 11. Laboratory test of seals and grease on journal roller bearings at 900 rpm.

Dilution of the grease can occur from water, brine, finely divided particles such as iron ore, phosphate and flour, and other contaminates passing through the seal. Laboratory tests have been confirmed by road service to indicate that this seal is effective in excluding such contaminates. The shape of the steel seal case helps divert contaminates from the dust lip which functions to further exclude foreign matter from the bearing. Some foreign deposits have been found between the dust and fluid lips but no detrimental percentage in the bearing grease. There have even been several cases of cars caught in flooded areas for days. Upon disassembly of the bearings under these cars the grease showed no abnormal water content. In one case some water was found in the bearing. Tests are under way toward expelling this water without taking the bearing apart.

ELECTRON OPTICAL STUDIES

The electron microscope has sufficient resolving power to show the changes in the primary form and arrangement of the fiber or particles in the soap structure which largely determine the behavior of grease subjected to mechanical work. The AAR Research Laboratory is finding their electron microscope studies of promising assistance for correlating with results from their more conventional laboratory grease tests and some of their findings are reported here.

These studies were made at 3000 magnification using a table model microscope. Grease samples were examined before and after laboratory tests in a simulated service roller bearing journal box used for qualifying grease (4). Here the sample preparation

was made by dispersing a small quantity of grease in n-hexane. A drop of this dispersion was placed on a 200-mesh copper screen which had a parlodian film for a substrate. The sample was then washed with several drops of n-hexane and dried. While this dispersion method is frequently used, other workers (5, 6) have used different procedures to leach out the oil phase; this is done without the danger of disturbing the fiber arrangement and washing away some of the shorter fibers as may occur in the dispersion method.

A sodium base grease is shown in Fig. 12 where the penetration was 347 before test and 432 plus, after test in a journal box for a number of revolutions equivalent to 47,000 miles. Here the sample was taken from the front roller path area where the ratio of fiber length (L) to width (W) was about 7.9. For comparison, a sample was taken from the bulk grease in the cover area which had an L/W value of about 7.0 but no micrograph for this condition is shown here. These studies showed that considerable size degradation occurred in the grease structure throughout the entire grease volume indicating that the bulk grease was

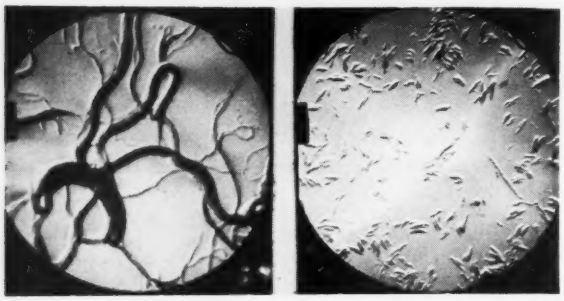


Fig. 12. Breakdown of a sodium base grease after test in a journal box for 47,000 miles. (Before test, left—after test, right)

circulating through the bearing. The loss in consistency evident from the measured penetration of 432 plus made this grease unacceptable under AAR Specification M-917-56.

Other investigators have showwn that grease samples generally exhibit the maximum degradation when taken from the roller path where the shearing action is most intense. There is little evidence to indicate that we need data on the consistency of the surface film of grease on the roller track as mechanical stability is not a pre-requisite for lubrication (7). Also since the bulk grease constitutes the major portion of the sample used in the physical tests for qualifying greases, additional micrographic studies in Figs. 13 and 14 were made from samples taken from the cover area in two different grease tests.

A lithium base grease is shown in Fig. 13 where the penetration was 366 before test and 330 after test in a journal box for a number of revolutions equivalent to 46,000 miles. There is little if any degradation of the fibers indicating that the grease bulk was not circulating through the bearing. This is one of the indications of a satisfactory roller bearing grease and it has been helpful in eliminating greases which thin out in service. This particular grease met AAR Specification M-917-56.

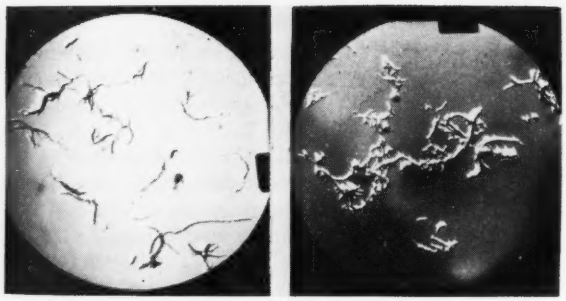


Fig. 13. Satisfactory lithium base grease after test in a journal box for 46,000 miles. (Before test, left—after test, right)

A calcium lithium base grease is shown in Fig. 14 where the penetration was 349 before test and 432 plus, after test in a journal box for a number of revolutions equivalent to 46,000 miles. The grease fiber lengths have been broken into short fragments indicating the grease bulk circulated through the bearing. This grease did not meet AAR Specification M-917-56.

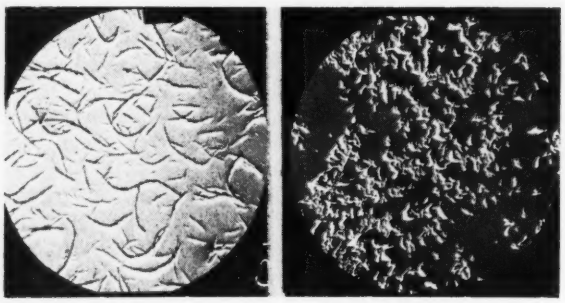


Fig. 14. Breakdown of a calcium lithium base grease after test in a journal box for 46,000 miles. (Before test, left—after test, right)

While electron microscope pictures before and after grease testing are a good indication of the suitability of the grease, it is not an infallible indication. It has been found that occasionally where there is some size degradation, a grease will still meet the specification regarding penetration. It is a matter of significance, however, that generally greases which break down in particle size do not pass this specification. Even though there is fragmentation of fibers due to shearing action in passing through the bearing there may be, at least partially, rejoining of the fibers when the grease comes to rest. With extensive fiber breakage the grease may not recover its structure (8).

Some greases have a very short fiber in their original state so that electron optical studies may not show this fiber breakdown. It is interesting to note that other investigators have not been able to find significant fiber breakdown in the grease worker test. Grease is subjected to a shearing rate several hundred times faster in a roller bearing than in a grease worker. It has been reported (9, 10, 11) that neither the ASTM Grease Worker Test or the Roll Test correlate with excessive fluidity experienced in service.

ACKNOWLEDGMENTS

The electron optical studies in Fig. 12, 13, and 14 were made available through the courtesy of W. M. Keller, Vice President of Research for AAR. CRC tests reported in Table 1 were taken from the work of H. Peeples, Lubrication Engineer, The Timken Roller Bearing Company.

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11. Higgins, E. M., "Correlation of ASTM Grease Worker Tests with Field Performance," NLGI Spokesman, v. 19, n. 9, Dec. 1955, pp 8-10.

DISCUSSION of O. J. Horger paper

by Wayne Lasky

Dr. Horger is to be complimented for his excellent presentation of the status of lubrication of railroad roller bearings.

We have attended several of the tear-down inspections of freight car roller bearings that had been in service three and four years without lubrication attention, including the bearings that had accumulated some 288,000 miles service on piggy back cars. Lubrication in all instances had been adequate and all bearing parts were found in excellent condition.

We are in agreement with Dr. Horger that a four year lubrication period appears possible and practicable. Details will have to be worked out as to the optimum amount of grease to be added to various types of bearings. This will be a function of the AAR Lube Committee.

We would like very much to agree with Dr. Horger that corrosion of inactive or stored bearing assemblies is not a problem. (Note first paragraph under Inactive Cars—quote: "It is not necessary to move cars or rotate bearings to prevent rusting of roller bearing journals or for any reasons associated with the use of roller bearings.") However, having had to explain to our management the failure of several roller bearing assemblies on our railroad that were the result of corrosion damage during storage, we are still not convinced that a substantial corrosion problem does not exist. The following figures show several of the bearings we have examined.

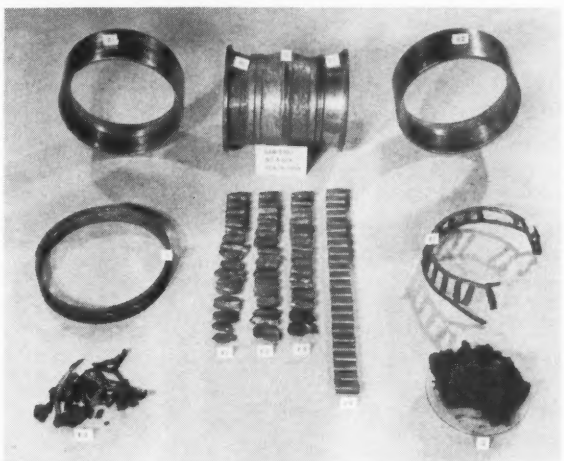

Fig. A-1 Failure of journal bearing due to water corrosion.

Fig. A1 shows the parts of a 5½ x 10 inch, quad type, grease lubricated bearing after failure on line of road. The failure was attributed to water corrosion that had developed during 20 months outside storage at St. Louis, Mo. This bearing failed after 75,000 miles or about 4 months in high speed passenger service. Although the surfaces of the rollers and cups were badly scarred, some evidence of pitting from corrosion was still visible.

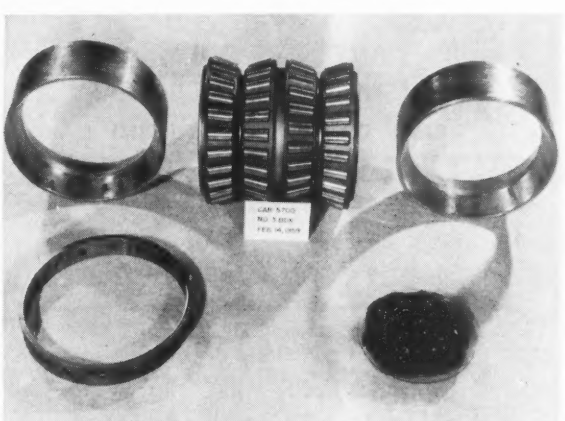

Fig. A-2 Bearing from opposite end of axle to that which operated with the bearing shown in A-1.

Fig. A2 shows some of the parts of the mate bearing on the opposite end of the axle. When the cover of this bearing was removed, about 2 ounces of water drained from the housing. The bearing was not in distress, but you can note numerous water stains on the contact surfaces of the cups and cones.

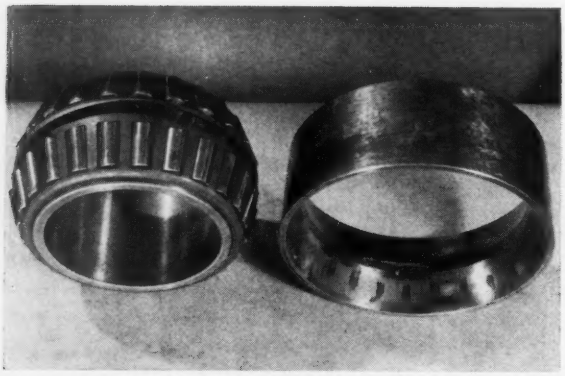

Fig. A-3 Close up view of cup and cone.

Fig. A3 is a close-up of a cone and cup. It can be seen that the heavy, wider stains on the roller path of the cup are rather evenly spaced about the same distance apart as the rollers in the cone. The discoloration in the non-contact area between the two roller paths contained considerable iron rust.

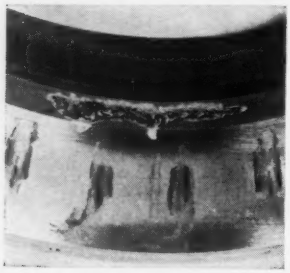

Fig. A-4 Close up view of roller path in cup.

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Fig. A4 is a close-up of the roller path of a cup. It can be seen that narrower corrosion marks are present in between the larger stains, indicating shorter periods of storage when the rollers were in different positions.

Fig. A-5 Close up view of area in Fig. A-4 after polishing.

Fig. A5 is a close-up of same area of roller path of cup shown in Fig. No. 4, after the surface involving 6 of the larger stains had been polished with fine abrasive paper and the stain marks removed. The dark lines in the polished area are actual metal surface damage (etching) resulting from rusting or corrosion. You will note that the damage or etching in all instances follows the perimeter of the stain marks shown in Fig. A4.

We estimate the etching to be .001 to .002 inch deep. In our opinion this bearing is not suitable for continued service.

Damage of this type shortens the fatigue life and service life of the bearing.

We realize this bearing is of different design than the present freight car bearing and has a labyrinth seal. We, however, have on numerous occasions observed water corrosion on bearings equipped with rubbing rubber seals. Although bearings may have adequate seals, water can accumulate in bearing housings by condensation of moisture from the air in the housing. Air changes in the bearing by "breathing" which is a result of changes in ambient temperature. Bearings stored in localities having a wide range of temperature between day and night and high humidity are more susceptible to corrosion.

We are also aware that the latest AAR Grease Specification requires a rust inhibitor, however a large percentage of the bearings now in service are operating with the older greases that are not rust inhibited.

We therefore consider bearing corrosion of inactive or stored bearings a definite possibility and railroads would be wise to adopt bearing handling and bearing maintenance practices that will *reduce* the possibility of extensive bearing corrosion during storage to a minimum.

AUTHOR'S CLOSURE

The statements made in my paper were not intended to imply that corrosion is not a problem. It is for the very reasons outlined in the discussion by Lasky that preventive steps suggested in the paper are being taken to improve this situation. The moving of cars or rotating of bearings as a means of preventing rusting is neither an engineering nor economical solution to the corrosion problem.

MORGOIL
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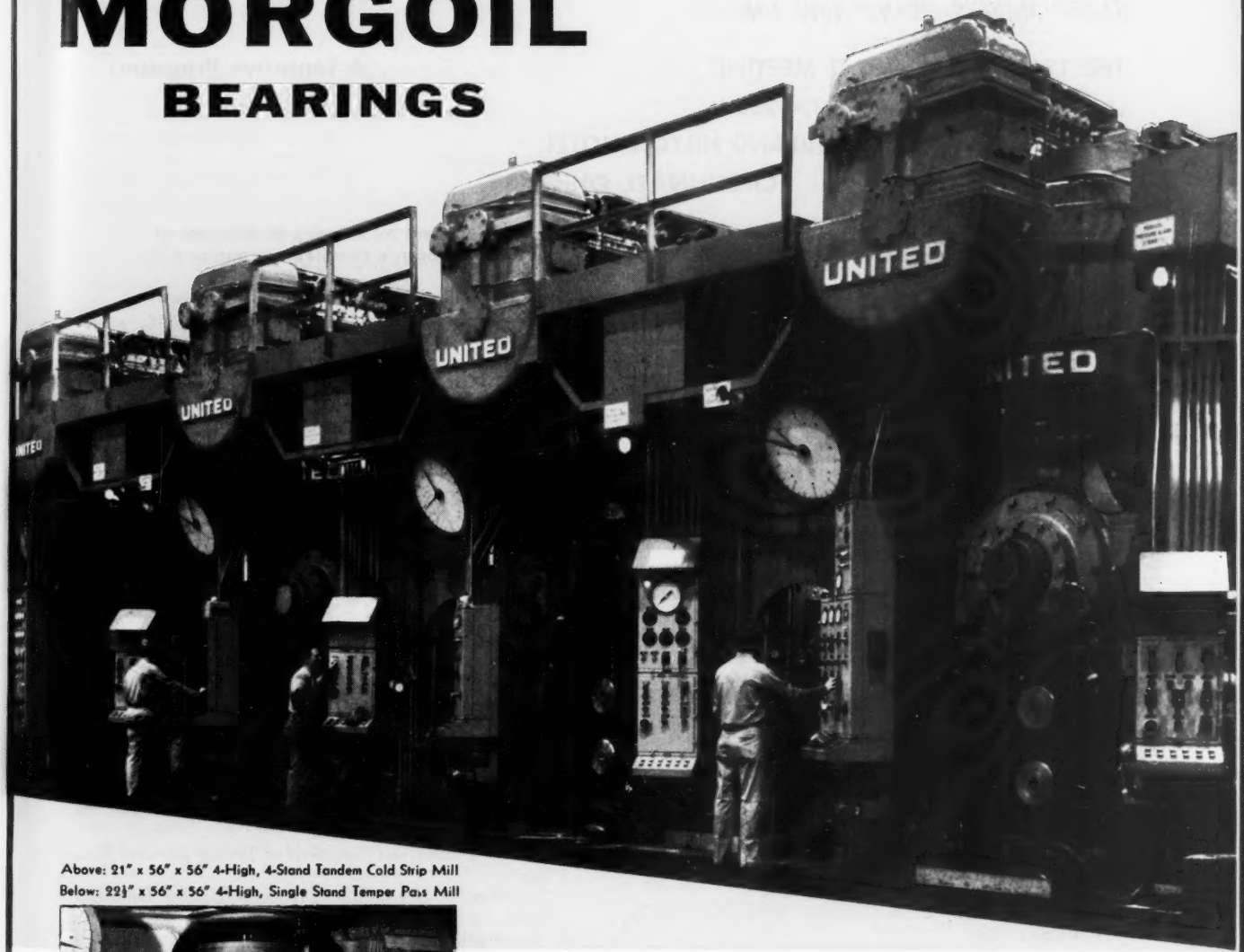
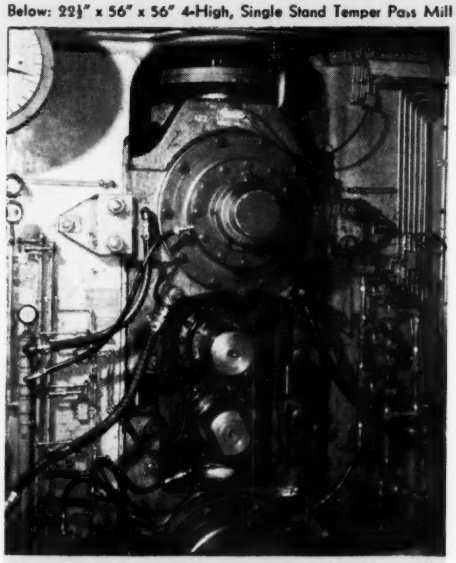


Above: 21" x 56" x 56" 4-High, 4-Stand Tandem Cold Strip Mill
Below: 22½" x 56" x 56" 4-High, Single Stand Temper Pass Mill



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APRIL 19, 20, 21, 1960

NETHERLAND HILTON HOTEL

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The importance of lubrication is becoming more and more apparent to industry in this age of space vehicles and nuclear development. The very existence of today's complex mechanisms is wholly dependent upon proper and scientific lubrication.
New techniques as well as new materials are constantly being developed to cope with high temperature problems. Resistance to radiation is an important factor in lubricant specifications. Other problems which have plagued the lubrication engineer are being more closely scrutinized in the hope that at last there may be answers to them.

Tuesday, April 19, 1960

Morning—9:00—ASLE Business Meeting

10:00—SEALS AND PACKINGS

R. W. Blair, Chicago Rawhide, Chicago, Illinois, Session Organizing Chairman.

1. "Testing Carbon for Seals and Bearings"
   R. R. Paxton, W. R. Shobert, Pure Carbon Co., St. Marys, Pa.
2. "Degradation of High Temperature Lubricants"
   J. J. Murray, E. P. Scanlan, Chicago Rawhide Mfg. Co., Chicago, Ill.

HYDRAULICS AND HYDRAULIC MACHINERY

K. G. Henrikson, Socony Mobil Oil Co., Inc., New York, N. Y., Session Organizing Chairman.

1. "Hydraulic Filter Requirements for Industrial Servo Systems"
   John A. Farris, Aircraft Porous Media, Inc., Glen Cove, N. Y.
2. "Training the User of Hydraulic Equipment"
   F. L. Mackin, General Motors Institute, Flint, Michigan
3. "Precise Duplication by Hydraulic Tracing"
   B. W. Carter, H. Horlacher, Cincinnati Milling Machine Co., Cincinnati, Ohio

LUBRICANT RECONDITIONING AND DISPOSAL

W. H. Craig, The Sharples Corp., Cleveland, Ohio, Session Organizing Chairman.

1. "Disposal and Conservation of Lubricating Oil by Re-Refining"
   A. B. Two, Motor Oils Refining Co., Lyons, Illinois
2. "Basic Fundamentals of Filtration"
   J. R. McCoy, Indiana Commercial Filters Corp., Lebanon, Indiana
3. "Centrifugal Purification of Lubricating Oil"
   Charles M. Ambler, The Sharples Corp., Philadelphia, Pa.
4. "Purification of Missile Hydraulic Oil"
   E. G. Bahret, The De Laval Separator Co., Poughkeepsie, N. Y.

Afternoon—2:00

RAILROAD LUBRICATION COUNCIL

L. E. Hoyer, American Brake Shoe Co., Mahwah, N. J. Session Organizing Chairman.

1. "Positive Control Flat Back Bearing"
   J. A. Zupez, American Brake Shoe Co., St. Louis, Missouri
2. "Application of Lubrication Experience to the Freight Car Journal"
   Edwin Crankshaw, Cleveland Graphite Bronze, Cleveland, Ohio
3. "Filtration of Lubricating Oil on Diesel Locomotives"
   T. J. Ames, Commercial Filters Corp., Ridgefield, N. J.

GENERAL SESSION

A. W. Lindert, Standard Oil Co (Indiana), Whiting, Indiana Session Organizing Chairman

1. "A Comparison of Lubrication Requirements of Nuclear Powered Surface Vessels and Stationary Power Plants"
   E. H. Okrent, Esso Research & Engineering Co., Linden, N. J.
2. "Use of Aluminum in Lubrication Systems—Design and Specifications"
   E. E. McDole, Kaiser Aluminum & Chemicals Corp., Ravenswood, W. Va.
3. "Lubrication Requirements of the Rotary Regenerative Air Preheater"
   Joseph Waitkus, The Air Preheater Corp., Wellsville, N. Y.

BEARINGS AND BEARING LUBRICATION

H. E. Mahncke, SKF Industries, Inc., Philadelphia, Pa. Session Organizing Chairman

1. "Plastic Yielding and Vibrations of Rolling Element Bearings"
   T. Tallian, O. G. Gustafsson, H. O. Walp, SKF Industries, Phila., Pa.
2. "An Investigation of Oils for Use in Helicopter Oscillating Bearings"
   L. A. Donnelly, Sikorsky Aircraft, Stratford, Connecticut
3. "Relaxation Phenomena In Lubrication"
   E. O. Forster, Esso Research & Engineering Co., Linden, N. J.

Wednesday, April 20, 1960

Morning—9:00

BEARINGS AND BEARING LUBRICATION

W. A. Gross, IBM Research Lab., San Jose, Calif., Session Organization Chairman

1. "Boundary Conditions of Cavitation Regions in Journal Bearings"
   Leif Floberg, Chalmers University of Technology, Gothenburg, Sweden
2. "Design and Use of Pneumostatic Bearings"
   Vance H. McNeilly, E. I. DuPont de Nemours & Co., Wilmington, Del.
3. "High Temperature Molten Salt Lubricated Hydrodynamic Journal Bearings"
   P. G. Smith, Oak Ridge National Laboratory, Oak Ridge, Tenn.

GEARS AND GEAR LUBRICATION

E. E. Shipley, General Electric Co., W. Lynn, Massachusetts Session Organizing Chairman

1. "Laboratory Evaluation of Automotive Gear Lubricants"
   S. R. Calish, California Research Corp., Richmond, California
2. "A Study of The Effect of Lubricants on Rubbing Metal Surfaces"
   A. A. Manteuffel, G. Wolfram, Pure Oil Research Center, Crystal Lake, Illinois
3. "Performance of EP Gear Lubricants in the Rear Axles of An Over-the-Road Truck Fleet"
   W. C. Brandow, The Lubrizol Corp., Cleveland, Ohio

PROPERTIES OF LUBRICANTS

C. A. Bailey, National Tube Division, U. S. Steel, Pittsburgh, Pa. Session Organizing Chairman

1. "Surface Active Agents as EP Conditioners"
   E. S. Reynolds, Socony Mobil Oil Co., Inc., New York, N. Y.
2. "Antiwear and Extreme Pressure Additives for Greases"
   S. F. Calhoun, Rock Island Arsenal, Rock Island, Illinois
3. "High Temperature Gas Turbine Lubricants"
   H. W. Adams, WADC, Wright Patterson AFB, Ohio

Wednesday, April 20, 1960

Afternoon—2:00

METALWORKING

M. Petronio, Frankford Arsenal, Philadelphia, Pa. Session Organizing Chairman.

1. "Lubricoolants—Their Secondary Aspects"
   R. K. Smith, S. J. Barber, E. F. Houghton Co., Philadelphia, Pa.
2. "Cutting Fluid Performance"
   I. Ming Feng, Amod Gujral, Ethyl Corp., Detroit, Michigan and M. C. Shaw, Massachusetts Institute of Technology, Cambridge, Mass.
3. "Brass Rolling Emulsions"
   R. W. Belfit, Sr., N. E. Shirk, Scovill Mfg. Co., Waterbury, Conn.

GEAR LUBRICATION—PANEL

D. W. Dudley, General Electric Co., Schenectady, New York, E. K. Gatcombe, U. S. Naval Post Graduate School, Monterey, Cal. E. S. Reynolds, Socony Mobil Oil Co., New York, N. Y.

ENGINE LUBRICATION

Dean C. Bardy, The Lubrizol Corp., Cleveland, Ohio Session Organizing Chairman

1. "Teflon Insert Compression Rings in Radial Gas Engines"
   D. W. Sawyer, D. A. Paull, Alcoa Research Laboratories, New Kensington, Pa.
2. "Bench Test of Cam and Tappet Wear in Additive Oils"
   E. H. Loeser, Chrysler Corp., Detroit, Michigan
3. "Measuring Oil Film Thickness in Engine Bearings"
   W. D. Sims, Shell Development Co., Emeryville, Calif.

Thursday, April 21, 1960

Morning—9:00

PROPERTIES OF LUBRICANTS

M. Ehrlich, American Lubricants, Inc., Buffalo, N. Y. Session Organizing Chairman

1. "Lubrication Problems Encountered in Space Vehicles"
   M. M. Freundlich, Airborne Instruments Laboratory, Melville, N. Y.
2. "The Effect of Environmental Conditions, Including Radiation, on the Performance of Greases"
   P. J. Agius, A. L. Morris, Esso Research Ltd., Abingdon, Berkshire, England
3. "Functional Requirements of Lubricants for Nuclear Powered Surface Vessels"
   E. H. Okrent, Esso Research & Engineering Co., Linden, N. J.

BEARINGS AND BEARING LUBRICATION

H. E. Mahncke, SKF Industries, Inc., Philadelphia, Pa. Session Organizing Chairman.

1. "Aircraft Accessory Bearing Operation at 500°C"
   Paul H. Bowen, Westinghouse Electric Corp., E. Pittsburgh, Pa.
2. "A Study of Oscillating Roller Bearings Operating in the Temperature Range 300°F to 600°F"
   W. A. Glaeser, Battelle Memorial Institute, Columbus, Ohio
3. "Operating Characteristics of 75 Millimeter Bore Ball Bearings at Minimum Oil Flow Rates Over a Temperature Range of 500°F"
   F. T. Schuller, W. J. Anderson, National Aeronautics and Space Administration, Cleveland, Ohio.

LUBRICATION EQUIPMENT

D. H. Wilson, Continental Steel Corp., Kokomo, Indiana Session Organizing Chairman

1. "Centralized Re-circulating Coolant Systems for Cold Rolling Operations in the Steel and Aluminum Industries"
   J. P. Wettach, Dravo Corp., Pittsburgh, Pa.
2. "Considerations of Centralized Lubrication for Lubrication of the Rings and Travelers on Spinning and Twister Frames in the Textile Industry"
   T. M. Murphy, Alemite Div., Stewart-Warner Corp., Chicago, Ill.
3. "Centralized Lubrication in the Steel Industry"
   E. J. Gesdorf, Farval Corp., Cleveland, Ohio
4. "Lubrication Equipment in the Metal Working Industry"
   Donald Wynocker, E. W. Baumgardner, Trabon Engineering Corp., Solon, Ohio.
5. "Lubrication Equipment in the Mining Industry"
   R. E. Crean, Lincoln Engineering Co., St. Louis, Mo.

Thursday, April 21, 1960

Afternoon—2:00

PROPERTIES OF LUBRICANTS

C. A. Bailey, National Tube Div., U. S. Steel, Pittsburgh, Pa. M. Ehrlich, American Lubricants Inc., Buffalo, N. Y. Session Organizing Chairmen.

1. "Friction Characteristics of Automatic Transmission Fluids as Related to Transmission Operation"
   M. L. Haviland, J. J. Rodgers, General Motors Research Labs., Warren, Michigan.
2. "Evaluation of a Fire Resistant Fluid in a Circulating Oil System"
   E. J. Tullos, Union Carbide Nuclear Company, Paducah, Kentucky
3. "Statistical Analysis of Lubricant Tests"
   J. J. Geissler, U. S. Steel App. Res., Monroeville, Pa.

MACHINE TOOL COUNCIL

D. R. Skudstad, Gisholt Machine Co., Madison, Wisconsin Session Organizing Chairman.

1. "The Transition from Boundary to Mixed Friction on Flat Sliding Bearings"
   R. L. Lenning, Cincinnati Milling Machine Co., Cincinnati, Ohio.
2. "Progress in the Identification and Standardization of Lubricants for Machine Tools"
   M. W. Papp, Warner & Swasey Co., Cleveland, Ohio.
3. "The Effect of Various Cutting Fluid Types on Residual Stress When Grinding High Temperature Alloys"
   D. H. Stewart, General Electric Co., Cincinnati, Ohio

LUBRICATION FUNDAMENTALS

W. E. Campbell, Consulting Chemist, Cleveland, Ohio, Session Organizing Chairman. *(Con't. on p. 88)*

This semi-annual publication can be obtained on subscription by ASLE members only at $5.00 per year; non-members may obtain the new Transactions from Pergamon Press Inc., 122 E. 55th St., New York 22, N. Y. Author's abstracts of the papers appearing in Volume 2, No. 2 follow:

Abstracts from ASLE Transactions

J. F. Batter and F. E. Reed, "Wear in Heavily Loaded Lubricated Surfaces Subjected to Oscillating Motion."

Specimens of materials used in dental couplings were tested in a simplified wear test machine which duplicated as closely as possible the actual wear conditions existing in operating couplings. The wear patterns that were obtained by tests of short duration on this machine duplicated those found in service. The results of tests covering the variables; load, speed, duration, amplitude of reciprocating motion, surface finish and hardness are presented, together with brief discussions of the effects of these variables.

D. L. Powell and H. R. Barton, "Sliding Velocity and Dynamic Loading of Automotive Hypoid Gears"

An experimental and analytical study has been undertaken to determine the lubrication environment of automotive hypoid gears under severe dynamic operating conditions. Results of an experimental investigation of gear loading and an analytical study of gear sliding under laboratory and field operating conditions in both automobiles and trucks are presented. The sliding relationships of four representative gears are discussed and the effects of changes in pinion offset and gear ratio on sliding velocity are studied. Increases in pinion offset and gear ratio both tend to increase the sliding velocity of hypoid gears. The present trends in automobile hypoid gear design are toward greater pinion offset and lower gear ratios. These two average trends are of opposite effect on gear sliding and tend to cancel each other. The sliding velocity of any particular gear set would have changed considerably in recent years if the design changes were primarily in one factor.

P. M. Ku and B. B. Baber, "The Effect of Lubricants on Gear Tooth Scuffing"

This paper discusses the effect of some lubricant variables and other relevant factors on gear tooth scuffing. Scuffing is defined as any form of scoring or abrasion of the tooth surface due to metal-to-metal contact. The scuff-limited load is defined as the tooth load at which an arbitrary amount of the working tooth area is scuffed. The factors considered include lubricant bulk viscosity, lubricant type and deterioration, test gear and test machine variables, gear speed, the location and rate of lubricant supply, lubricant supply temperature, and the presence of inert gas atmospheres. The results are compared with, and examined, in the light of other published data.

A. Cameron, "A Theory of Boundary Lubrication"

The mechanism of boundary friction is assumed here to be due to the molecular forces between hydrocarbon molecules adsorbed on the surfaces rather than to welding and tearing of the opposing surface roughnesses. On this assumption the frictional force, which arises when two orientated layers are moved over each other, can be calculated. The formulae for the Van der Waals' and the repulsion forces are those successfully used by Müller for paraffins. The different values of the kinetic and static frictions can be explained by the forces being due to the tails of the chains in kinetic and the sides of the chains in static lubrication.

The value of the coefficient of friction, as calculated by this method, is of the correct order of magnitude.

E. H. Loeser, R. C. Wiquist and S. B. Twiss, "Cam and Tappet Lubrication IV—Radioactive Study of Sulfur in the E. P. Film"

A radioactive tracer, sulfur-35, synthesized into zinc dialkyl dithiophosphate molecules, was used to study the EP film formed on cast iron cams and tappets run in motor oils containing this additive. The sulfur content of static films increased with immersion time and temperature, and the presence of phosphate coated metal surfaces. The bound sulfur of films formed during dynamic tests increased with running time, load, and with the use of phosphate coated surfaces. These conditions also influenced the ratio of Zn:P:S contained in both static and dynamic films. Zinc, and particularly phosphorus in the films increased more rapidly than the sulfur with increased temperature and/or pressure. The dynamic films are not easily worn off by running in non-additive oil. The mechanism of action of zinc dithiophosphates appears to be related to chemical reactions of additive decomposition products with the metal surfaces to form tightly-bound solid films which reduce damage under extreme pressure conditions. Radioactive counting and X-ray spectroscopy were used to obtain the amount of sulfur and zinc on tappets. Densitometer traces of the autoradiographs were utilized to determine the distribution of the sulfur on cam and tappet surfaces.

T. W. Selby, "Low Temperature Behavior of Motor Oils"

The behavior of motor oils at low temperatures is obviously important to the performance of the motor. Low temperature cranking speeds have been shown to be dependent on the viscosity, and in a previous paper the author has shown that the viscosity characteristics of motor oils at these temperatures may be unusual, especially when they contain Viscosity Index Improvers.

In this paper the author has analyzed the results of 250 cranking tests conducted at temperatures from +3 to −35 F. These results were compared using the viscosities as determined in a moderate shear viscometer and as extrapolated and calculated by the ASTM chart and a recently published analytical technique.

S. L. Cosgrove, L. B. Sibley and C. M. Allen, "Evaluation of Dry Powdered Lubricants at 1000 F in a Modified Four-Ball Wear Machine"

The friction and wear behavior of selected solid lubricants and wear specimens has been studied in a modified four-ball wear machine. Data were ob-

tained at 1000 F for sliding speeds of 120 and 700 feet per minute under initial Hertzian contact stresses of about 250,000 psi.

Conventional solid lubricant materials such as lead oxide (litharge), molybdenum disulfide, and graphite were evaluated. A new dry solid lubricant, metal-free phthalocyanine, was studied and was usually found to have superior lubricating ability. Wear specimens of AISI Type M-1 tool steel and titanium carbide-nickel-molybdenum cermet showed the most promise for high-temperature sliding systems. Initial coefficients of friction less than 0.1 were obtained with combinations of these materials.

M. G. Peterson, J. J. Florek and S. F. Murray, "Consideration of Lubricants for Temperatures Above 1000 F"

A study has been made of the various solid and liquid lubricants which could be considered for use to temperatures above 540 C. This study consisted of a literature survey to isolate temperature stable, low shear strength compounds, and some experimental work to evaluate the most promising materials. Many of these compounds were effective at high temperatures and the results can explain the compatibility of certain metals at high temperatures. These compounds were not effective at lower temperatures. A more detailed study was made of the sliding characteristics of metals when lubricated with silver and molten boric oxide. The results show that, for silver, a number of factors such as choice of bearing materials, strength, and impurities affect the frictional behavior. Boric oxide, under conditions of boundary lubrication, showed a large increase in friction when the viscosity increased above 2400 poises. Variations in the friction could be explained by independent variations of viscosity and shear area.

No lubricants were isolated which could be considered completely effective for a temperature range from 27 C to above 540 C. The choice of bearing materials and designs will have to be made to minimize these deficiencies.

A. H. Burr, "The Effect of Shaft Rotation on Bearing Temperatures"

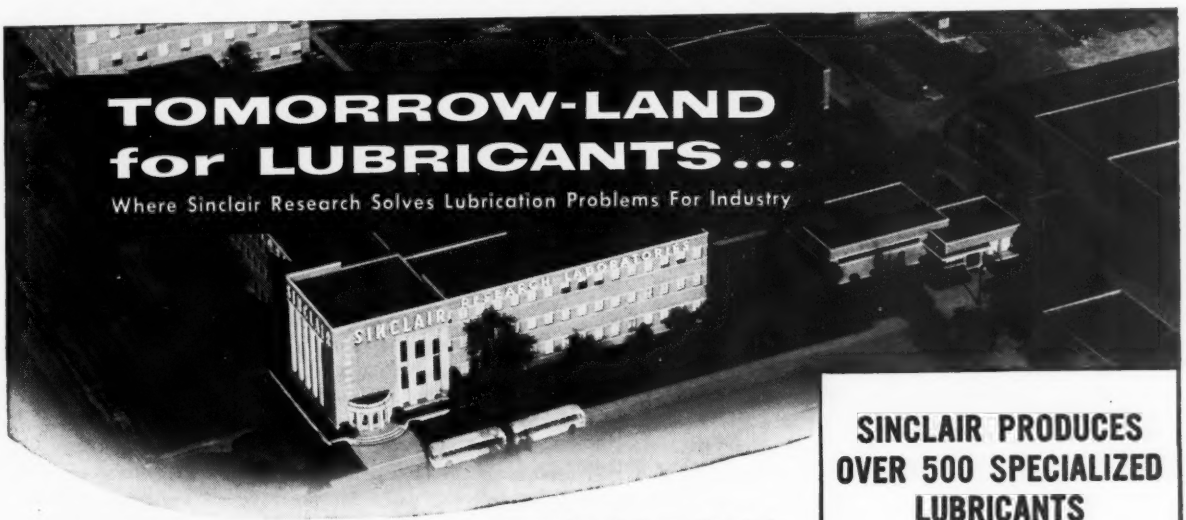
Heat transfer data from recent studies of rotating cylinders are utilized in the heat balance method of predicting oil film temperatures for shaft and plain bearing combinations. Good agreement is obtained between calculated temperatures and experimental values. It is shown that the heat which is dissipated from a rotating shaft may be much greater than that from a stationary shaft and from the bearing housings, and it may be the major path for heat dissipation in certain cases.

M. Jacobson and E. A. Saibel, "The Finite Fitted Partial Journal Bearing"

An exact solution is found for the finite fitted journal bearing. Numerical calculations are carried out for an arc of sixty degrees and an arc of one hundred and twenty degrees for various positions of the bearing. A comparison is made of the load, pressure distribution, and friction force for the finite bearing and the infinite bearing (no side flow). It is concluded that in general the neglect of side flow yields a solution that may be in great error.

B. Sternlicht and H. Apkarian, "Investigation of Melt Lubricant"

This paper describes an experimental investigation of the physical phenomena occurring at the interface of high speed electrical sliding contacts. Special attention was focused on wear and energy dissipation at the interface of different sets of rubbing materials. This condition has been described by the term "Melt Lubrication." An attempt to give analytical predictions of the behavior of a set of originally solid materials sliding on each other is made by applying known analytical results from related fields.



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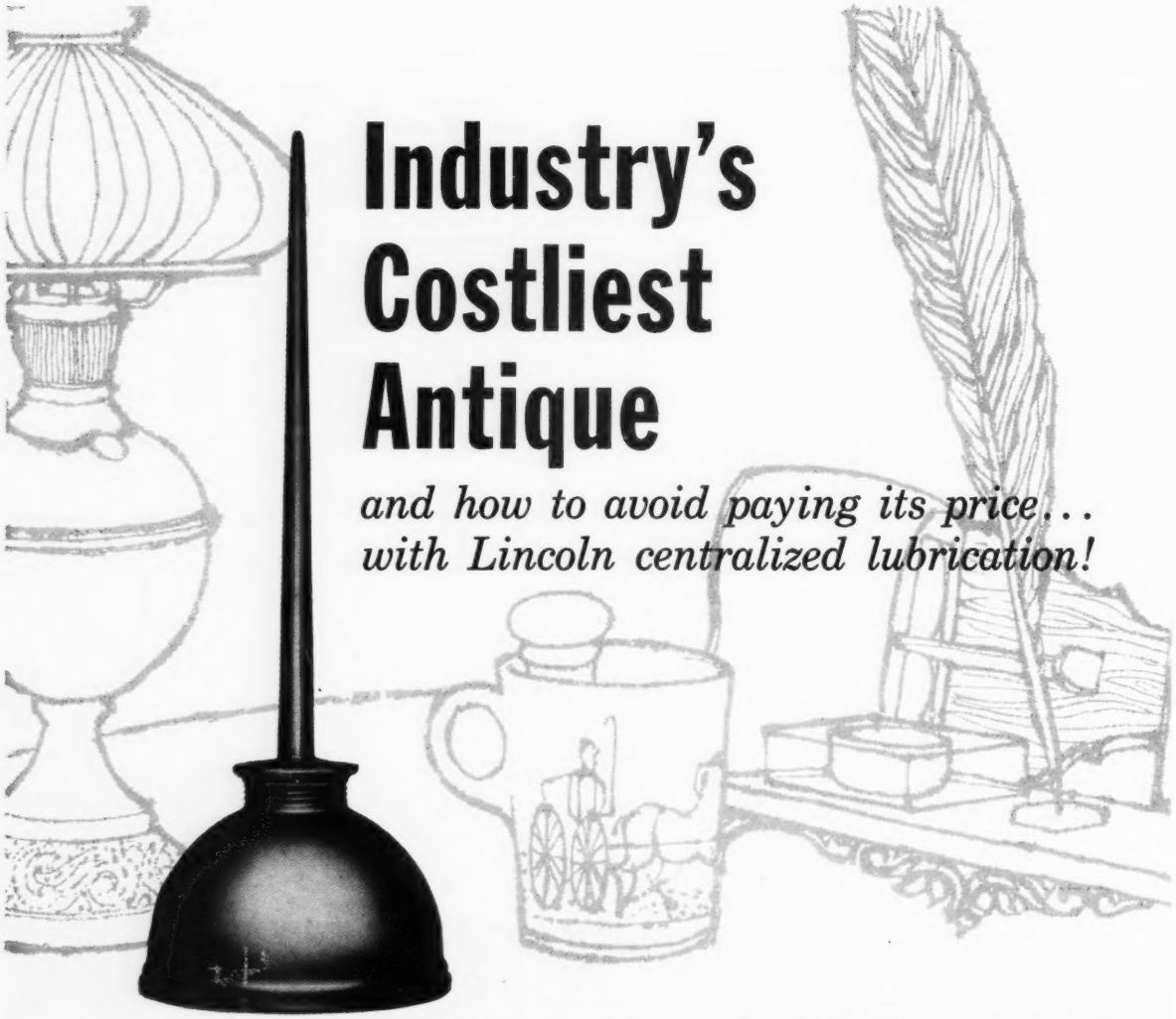

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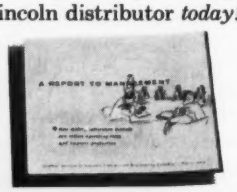

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Patent Abstracts

Compiled by Ann Burchick
Aluminum Co. of America

Process for the Preparation of Greases Gelled with Polymer Coated Clays, Patent #2,829,100 (J. W. Armstrong and D. M. Preiss and J. A. Edgar, assignors to Shell Development Co.) In the process for the formation of a grease composition, wherein a clay hydrogel is filtered from the majority of the water present therein, the remaining water is displaced by a water-miscible organic solvent, a grease-forming proportion of an organosilicone fluid having a lubricating oil viscosity is added and the solvent removed by evaporation, the improvement comprising adding 5-200 per cent by weight based on the clay of an aminoplast-forming monomeric amino compound, having at least two primary amino groups per molecule adjacent to carbon atom having a double bond, prior to filtration whereby a clay hydrogen of improved filterabilty is formed, adding 1.5-4 mols, per mol of amino compound, of an aminoplast-forming aldehyde subsequent to water displacement and heating the mixture, subsequent to solvent removal for four-48 hours at 100-250 C, whereby a grease composition having improved water resistance is formed.

Sulfurized Cutting Oil Compositions, Patent #2,829,101 (J. Rinse, assignor to Sulfo-Inc.) A sulfurized cutting oil comprising a mineral oil having the properties required for use in cutting oils containing finely divided sulfur suspended therein by the presence of a small amount of an ester of hydroxy stearic acid having up to eight carbon atoms in the esterifying radical.

Method of Forming a Sacrificial Lubricating Layer, Patent #2,830,017 (J. J. Shyne and F. Fahnoe, assignors to Vitro Corp. of America) The method of forming a sacrificial lubricating layer upon a selected surface of a metallic structure, said method comprising the steps of electrophoretically codepositing a mixture of a metallic matrix forming material of the group consisting of silver oxide and nickel oxide and a solid lubricant of the group consisting of the sulfides, disulfides, selenides and tellurides of molybdenum, out of a liquid organic medium upon said surface, the amounts of said matrix forming material and solid lubricant producing a layer having 70-80 per cent by weight of metallic matrix and 30-20 per cent of solid lubricant, and heating said structure in a gaseous atmosphere at a temperature to reduce said matrix forming material to form a metallic matrix which is bonded to said surface of said metallic structure, and which entraps and bonds said lubricant to said metalic structure.

Additive for Mineral Oil, Patent #2,830,019 (E. K. Fields and A. E. Brehm, assignors to Standard Oil Co.) A hydrocarbon oil composition comprising a major proportion of a liquid petroleum distillate and between about 0.0003 and about two per cent by weight, based on composition of an amine salt of an amino-carboxylic acid obtained by intermingling, at a temperature between about 30 C and about 200 C such that a reaction product is obtained, a molar ratio of amine to acid between about 0.5 and 1.5 of the stoichiometric requirement to react all the carboxylic groups in the acid, (A) an amine selected from the class consisting of (1) aliphatic amines wherein one alphatic group contains at least eight carbon atoms and (2) imidazolines having an aliphatic substituent containing at least eight carbon atoms, with (B) an amino-carboxylic acid.

Lubricating Oils Thickened with Metal Salts of Cyanuric Acid, Patent #2,830,020 (L. J. Christmann and W. G. Deichert, assignors to American Cyanamid Co.) A grease composition comprising a major proportion of an oil and, as a thickening agent therein, a minor quantity within the range of from about three to about 20 per cent by weight of a salt of cyanuric acid.

Lubricant Containing an Aliphatic Amine Salt of Monoalkyl Ester of a Dimeric Acid, Patent #2,830,021 (H. G. Smith and T. L. Cantrell, assignors to Gulf Oil Corp.) A mineral oil composition comprising a major amount of a mineral oil and a minor amount, sufficient to impart corrosion inhibiting properties to the composition, of an amine salt of (1) an aliphatic amine having at least one N—substituent containing from six to 26 carbon atoms and (2) a monoalkyl ester of a dimeric acid, said dimeric acid being derived from an unsaturated fatty acid containing from six to 22 carbon atoms and having from two to three ethylenic linkages per molecule.

Method of Grease Manufacture with Recycle Cooling, Patent #2,830,022 (R. F. Nelson, R. C. Givens and H. J. Pitman, assignors to The Texas Co.) The method of grease manufacture which comprises providing a molten homogeneous mixture of a lithium hydroxy fatty acid soap and an oleaginous liquid in grease forming proportions at an elevated temperature above the melting point of the soap, and controlling the crystallization of the said soap during cooling by maintaining a body of relatively large volume of the said mixture with agitation while reducing the temperature thereof until a grease consistency is obtained by continuously withdrawing a stream of relatively small volume from said body of mixture, passing the said stream through an external cooler where it is cooled to a temperature below the gelation temperature of the said mixture and returning the said cooled stfeam to the maintained body of mixture.

Complex Ester-Phosphorus Sulfide Reaction Products and Lubricants Containing Them, Patent #2,830,023 (M. F. Hoare, assignor to Esso Research & Engineering Co.) As a new composition of matter a product obtained by reacting a phosphosulfurizing agent selected from the group consisting of phosphorus sulfides and a combination of the elements sulfur and phosphorus with a lubricating grade complex ester at an elevated temperature, said ester being derived from esterification reactions between about two moles of a dicarboxylic acid selected from the group consisting of sebacic and adipic acid, about two moles of an aliphatic branched chain saturated C_3 to C_9 monohydric alcohol and about one mole of a polyethylene glycol up to hexaethylene glycol.

Extreme Pressure Gear Lubricant, Patent #2,830,024 (P. R. Chapman and A. A. Manteuffel, assignors to The Pure Oil Co.) A lubricant additive consisting of a mixture of about three-five parts by weight of sulfurized methyl esters of tall oil acids, said sulfurized product containing about three per cent to ten per cent by weight of sulfur acid being obtained by the reaction of methyl esters of tall oil acids with elemental sulfur at a temperature 20-30 F below the flash point of said esters until a product is obtained which is non-corrosive to a polished

copper strip when in contact therewith for about one minute at a temperature of 300 F, about one part by weight of phosphorized glyceryl trioleate, said phosphorized product containing about 0.97 weight per cent of sulfur acid about 1.26 weight per cent of phosphorus and being obtained by reacting glyceryl trioleate with phosphorus sesquisulfide at a temperature of about 220 to 230 F until a product is obtained which is noncorrosive to a polished copper strip when in contact therewith for about three minutes at a temperature of 210 F, and about 0.1 to 0.5 part by weight of a chlorinated naphthalene containing about ten to 40 per cent by weight of chlorine, said mixture being characterized by its stability during storage at room temperatures and at a temperature of 32 F.

Lubricating Compositions Containing Monomeric Condensation Products of Alkylated Phenols with Carbonyl-Containing Compounds, Patent #2,830,025 (E. C. Knowles, J. A. Patterson and H. D. Kluge, assignors to The Texas Co.) A lubricant composition comprising a major amount of a mineral lubricating oil and 0.1 to 5.0 per cent by weight, sufficient to confer antioxidant properties to the composition, of a compound selected from the class consisting of 1, 1 — bis (2 — hydroxy —3 — tertiary butyl — 5 — methylphenyl) n — butane, 1,1 — bis (2 — hydroxy — 3 — tertiary butyl — 5 — methylphenyl) isobutane and 1,1 — bis (2 — hydroxy — 3 — tertiary butyl — 5 — methylphenyl) — 2 — trichloroethane.

Lubricating Compositions, Patent #2,830,-950 (C. E. Rannefeld, assignor to Continental Oil Co.) A lubricating composition comprising from about two to five per cent of an oil soluble calcium diwax-benzene sulfonate, at least 0.15 per cent sulfur as phosphorus penta sulfide treated wax olefin, from about three to six per cent of a product obtained by reacting a hydroabietyl alcohol wherein said alcohol comprises a mixture of hydrogenated abietyl alcohols containing a non-alcohol fraction amounting to about 13 to 15 per cent and the alcohol fraction comprising about 15 per cent dehydroabietyl alcohol, about 40 per cent dihydroabietyl alcohol and about 45 per cent tetrahydroabietyl alcohol with an amount of barium oxide in excess of that which will react stoichiometrically with said alcohol in a lubricating oil under an inert atmosphere and at a temperature of 205 to 225 C, and the balance a mineral lubricating oil.

Production of Anhydrous Calcium Grease, Patent #2,831,811 (M. M. McCormick and J. W. Nelson, assignors to Sinclair Refining Co.) In the preparation of anhydrous calcium grease compositions wherein a mineral lubricating oil is thickened to grease consistency with a calcium hydroxy stearate, the steps of forming a heterogeneous mixture, at a temperature from about room temperature to 110 F, of hydroxy stearic acid, lime to saponify the fatty component and form a soap, about 0.2 to 2.0 parts by weight of water based on the fatty component and about two to four by weight of a mineral lubricating oil based on the fatty component, heating the mixture to provide a thickening of the oil at about 120 F to 145 F and an initial formation of soap below the melting point of the acid, raising the temperature to about 190 F while the saponification goes to substantial completion, evaporating free water from the mass, adding from about three parts to the total amount of the remainder of the oil of the final composition and then dehydrating the grease at a maximum temperature of below about 260 F.

Lubricants for Coating and Working Light Metals, Patent #2,831,782 (C. M. Zvanut, assignor to The Dow Chemical Co.) In a method of hot working the light metals, aluminum, magnesium, and alloys containing at least 70 per cent by weight of one of such materials by the action of a tool, said method being carried out at a hot working temperature above about 450 F, the improvement which consists of controlling tool contamination and the effects thereof by applying to the surface of the light metal to be worked a substance selected from the class consisting of alkali and alkaline earth metal monoalkyl phosphates having from eight to 20 carbon atoms in the molecule, said substance being stabilized against thermal decomposition by incorporation therein of an effective amount of a hydroxide selected from the class consisting of alkali and alkaline earth metal hydroxides.

Detergent Lubricating Composition, Patent #2,831,810 (C. E. Wilson, assignor to Union Oil Co. of California) A mineral lubricating oil having detergent characteristics consisting essentially of a mineral lubricating oil containing small amounts, between about 0.5 per cent and 15 per cent by weight, sufficient to impart detergency characteristics to said oil of phenyl biguanide oil-soluble petroleum sulfonate.

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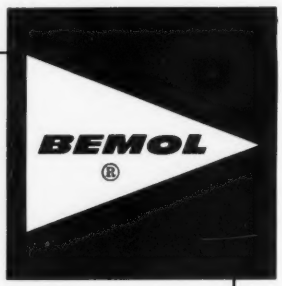

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Lubrication Abstracts

Edited by W. E. Campbell

Selected literature compiled by members of the Technical Committees and Industry Councils of the Society.

"Lubrication and Testing of Lubricants at High Temperatures." A. Bartel (Institute for Petroleum Research, Hanover, Germany), VDI Zeitschrift, v. 101, no. 8, March 11, 1959, p. 318. (In German).

Diagrams and brief descriptions are given of two test apparatus, developed at Hanover, for the investigation at temperatures to 1000 C of solid lubricants, e.g., glass, water-soluble eutectoid salt mixtures. The friction measuring lubricant tester uses a single replacable journal bearing mounted on a swivel beam in such a manner that the frictional torque is transmitted to a calibrated bow spring and is measured by a dial indicator. Unique features are the funnel-shaped hole in the bearing through which the solid lubricant is fed to the rubbing surfaces and the chain-driven shaft through which the load is applied to the bearing. A Silit-resistor rod fills the hollow of the test shaft and can maintain the test area at 800 C for as long as seven hours. The bushings of this shaft through which the electric current is supplied to the heater are of graphitic carbon covered with a molybdenum disulfide film. The wear apparatus consists of a pivoted loading arm on which is mounted a small block of the test material. This is pressed upwards against a test shaft similar to that described above. No data are given about the load range, the bearing material, the friction nor the wear results. These will be in subsequent papers. (*Abstracted by E. H. Loeser*)

"Oxidation of Gear Lubricants Laboratory and Field," M. J. Pohorilla and W. Hart (Kendall Ref. Co.). Am. Soc. Testing Matls—Bul. no. 234 Dec. 1958 pp. 45-7.

The procedure and equipment for a simple laboratory test for the evaluation of the oxidation stability of gear lubricants is designed to simulate the environment to which the lubricant is exposed in a gear case. This test has been shown to correlate with field experience with inhibited straight mineral oil systems. It also indicates that the proposed Multipurpose-Type Gear Lubricants (API Service GL-4) may be less stable to oxidation than the current products. In a period of increasing temperatures in transmissions and differentials, this is a factor which should receive further attention. (*Abstracted by E. O. Forster*)

"Consistency of Semi-fluid Greases," by J. O. Cliffe and J. W. Pearson (Shell Res. Ltd.) Inst. Petroleum—J. v. 45 no. 424 Apr. 1959 pp. 111-17.

The value of various laboratory tests for measuring the consistency of "semi-fluid" greases has been assessed by correlating the results of these tests with subjective judgments of consistency by a "consumer panel" of nine observers. A restricted statistical analysis of the results shows that the consistency of most of the "semi-fluid" greases examined could be adequately controlled using one or the other of two simple tests. For the stiffer grades, the Inst. Petr. penetration offers adequate control, while the softer grades are best controlled by using a simple plunger rheometer designed for measuring the apparent viscosity of non-Newtonian materials over a range of apparent rates of shear. With only one grease are these tests unsuitable—this is a grease of low yield value based on a very viscous oil blend. The MacMichael viscometer and the tapered-hole disk penetrometer described by Hotten and Birdsall are found to be of very limited application. Other forms of cone or cylinder penetration methods are found to offer no advantages either in scope or convenience over the Inst. Petr. method. A "universal cone" developed in the U.S.A. after this work was done should extend the range covered by the normal Inst. Petr. penetration. It is still unsuitable for very soft semi-fluid greases. (*Abstracted by E. O. Forster*)

"The Oxygen Absorption Characteristics of Inhibited Transformer Oils" by L. Massey (Research Dept., Metropolitan-Vickers Electrical Co. Ltd.) and A. C. M. Wilson. J. Inst. Petroleum, v. 44, no. 418, 1958, pp. 336-56.

A static oxygen absorption test procedure is described. It is used to evaluate the stability of several base oils and oils inhibited with amine and phenolic additives. Variables studied include include inhibitor concentration, soluble and metallic copper catalyst concentration, and temperature over the range 80-150 C. Among the conclusions drawn regarding the effects of these variables is the suggestion that the test can be used to determine the approximate remaining useful life of an oil in service. The useful life is defined as the period required to absorb 300 ml of oxygen per 100 gms oil, which corresponds to the oil attaining a neutralization number of 1.0 (*Abstracted by M. I. Smith*)

"Contribution to the Study of Lubricated Friction." J. Baudry (Institut Francois du Pétrole) Rev. inst. franc. pétrole et Ann. combustibles liquides, v. 12, no. 9, 1957, pp. 950-994. (In French)

This long paper describes research with an experimental journal bearing operating under boundary or thin film (the author calls it semifluid) conditions. The constitutional variables studied are types of oil, oiliness, and viscosity. The operational variables studied are temperature, load, velocity, and surface conditions. Coefficient of friction is measured.

The importance of high viscosity index (V.I.) is first established from thermal stability studies under thin-film conditions and variation of the oil, additives, viscosity, load, velocity, and surface conditions. A concept is developed on the critical conditions of seizure, where seizure is defined as the occurence of alternate welding and rupture of asperities.

The elevation in temperature observed with seizure depends on the value of the product of load, velocity, and coefficient of friction. The effect of additives on bearing performance indicate the preponderant influence of viscosity of adsorbed films at the interface under thin-film, low-velocity conditions. Frictional forces are inversely proportional to the square of the distance between the surfaces. Experimental results agree with theoretical calculations.

The mechanical efficiency of an engine as a function of viscosity is studied to verify the hypothesis. Engine power is measured with a "stroboscopic manograph" which is described in the paper. The use of additives which increase the viscosity of the film at high temperatures and loads protects against seizure. (*Abstracted by Douglas Godfrey*)

"The Low Temperature Liquid Phase Oxidation of Hydrocarbons: A Literature Survey" by F. Morton (College of Science and Engrg., Manchester) and R. T. Bell. J. Inst. Petroleum, v. 44, no. 417, 1958, pp. 260-72.

A good review of the field, covering 65 references. (*Abstracted by M. I. Smith*)

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The Annual Education Course Program will be listed in next month's issue.

"Friction and Dry Wear in Relation to The Physical and Chemical Properties of Superficial and Subjacent Layers" (In French), by G. Bellanger. *Rev. inst. franc. petrole.* v. 13, no. 10, 1958, pp. 1481-1484.

Friction and wear measurements of unlubricated steel sliding on steel when plotted against sliding distance give characteristic curves. The graph is divided into three zones. The first zone shows friction rising from 0.2 to 0.5 and very low wear, which the author attributes to contaminants and small metallic crystals. The second zone shows friction rising to a value between 1.0 and 1.6 and wear increasing to values 1000 times the rate in the first zone. The effect is due to metal to metal contact and strong welds. The third zone shows a reduction in friction and wear leveling off toward a high and constant value, attributable to the formation of oxides on the surfaces which are not part of the area of real contact at a given moment of sliding.

Sliding in the presence of gases changes the wear pattern in the second zone. Wear reduces considerably in the presence of oxygen, and reduces further in the presence of carbon dioxide, hydrogen sulfide, or chlorine. No wear is observed in the presence of moist chlorine. The author explains the wear patterns in terms of the physical properties of the reaction products of the gases and the steel. (*Abstracted by Douglas Godfrey*)

"Practical Design Approach to Oscillating-Load Bearings" by D. J. Myatt. Machine Design, v. 30, no. 25, Dec., 1958, pp. 133-6.

Operating characteristics, design calculations, and practical limitations are given of partial-revolution bearings of wrist-pin type. (*Abstractor, Engineering Index*)

"Instrument Precision Ball Bearings." Am. Standards Assn., Am. Standard no. B3. 10-1959, Jan. 2, 1959, 11 pp. Sponsor: Mechanical Standards Board.

The standard establishes characteristics which define instrument precision ball bearings, boundary dimensions and tolerances, classifications used for selective assembly, internal clearances, and other requirements as they may be developed. (*Abstractor, Engineering Index*)

"American Standard Method of Evaluating Load Ratings for Ball and Roller Bearings." Am. Standards Assn., Am. Standard no. B3.11-1959, Jan. 6, 1959, 19 pp. Sponsor: Mechanical Standards Board.

Methods of evaluating dynamic and static load ratings for radial ball and roller bearings, thrust ball bearings, and thrust roller bearings are given. (*Abstractor, Engineering Index*)

"The Importance of Microfiltering Lubricating Oils and the Life of the Modern Motor." H. Koenigs, Automobiltechnische Zeit, v. 60, no. 7, July 1958, pp. 206-9. In German.

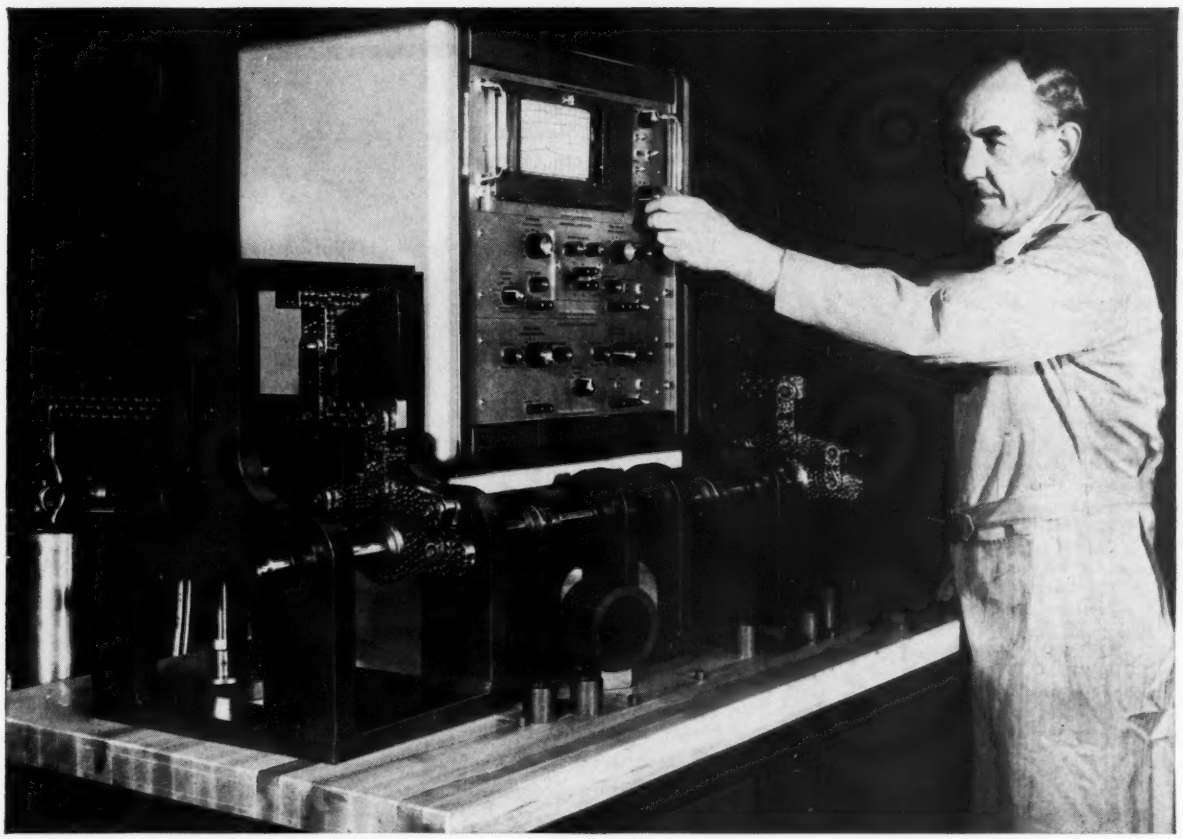
The modern development of internal combustion engines, which has increase in engine life as its main goal besides increase in speed, economy, and quieter running engines, has placed high requirements on the quality and functioning of the lubricants. Transition from non-additive to additive type oils has reduced the degree of filtering in the conventional oil filter, because the detergent and dispersant additives in the oil prevent the dirt particles from coagulating. For this reason the buildup of sludge on the top of the filter which aids in the filtering action has been slowed down or completely prevented. The use of the now generally adopted microfilters makes possible the filtration of present day oils without removal of the additives. The effectiveness of bypass and full-flow microfiltration is evaluated by means of wear tests. Examples of installations on both gasoline and diesel engines are given. (*Abstracted by D. W. Sawyer*)

"Determination of Acidity in Dark Lubricating Oils." W. Gibb and H. Gibson, Petroleum (London), v. 22, July, 1959, pp. 257-62.

The oxidative deterioration of mineral lubricating oils during use in an internal combustion engine may be estimated from the acidity of the oils. Three methods of determining this acidity are described: ASTM D664 potentio-metric, IP 139 color indicator and a new masked-fluorescent method. In the last, the oxidized oil is dissolved in a 1 to 1 mixture of n-butyl alcohol and toluene. The oil solution with fluorescin and methyl red indicators added is titrated with standard sodium butoxide. On the acid side of the neutral point, the methyl red masks the green fluorescence which develops strongly when the solution becomes alkaline. For slightly oxidized, light-colored oils the fluorescin-methyl red end point is inferior to that of the IP 139 standard indicator. For badly oxidized, dark oils the fluorescent end point is superior and the result is as accurate as that given by the potentiometric method. (*Abstracted by E. H. Loeser*)

"High Temperature Solid Film Lubricants for Uses Above 1000°F" by R. E. Crump (Electrofilm, Inc.) *SAE Paper* no. 45 Detroit Meeting Jan. 1959.

A procedure for applying a graphite-lead oxide mixture in a ceramic binder is outlined. Some friction and wear results are given.



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INDUSTRY NOTES

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Cleveland Worm & Gear and Farval were acquired by Eaton on January 31, 1959, and since then have been operated as subsidiaries.

Effective January 1, 1960, Henry H. Cross Co. and Henry H. Cross Co. of Arkansas are under new ownership. As of that date, Harry P. Dunn Co., Charles J. Wood & Associates, Inc., and National Wax Co. jointly purchased all of the physical assets of the Cross companies from the former principal owner, George F. Fox, and immediately assumed control of the operations. The Cross companies will carry on their business as in the past, completely independent of the above-mentioned ownership companies.

Charles J. Wood, the new president of the Cross companies, states that no personnel or policy changes are anticipated. Under the new management, company offices will be maintained at the same locations.

The following employees who have been connected with the Cross companies for many years will continue in the following managerial capacities: **J. N. Waddell**, general sales manager; O. B. Bingham, general manager of the Smackover, Ark. operations, with N. R. Price remaining as refinery superintendent. W. R. Tews becomes treasurer.

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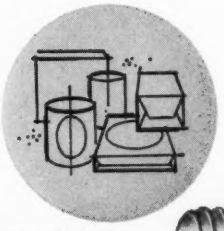
   K. P. Zeman, L. F. Coffin, Jr., General Electric, Schenectady, N. Y.
2. "Fundamental Processes in Lubricating Metal Surfaces at 1000°F to 1700°F"
   E. N. Klemgard, Washington State University, Pullman, Washington.
3. "Solid Lubricant Compositions for Use at High Sliding Velocities in Liquid Nitrogen"
   D. W. Wisander, R. L. Johnson, NASA, Cleveland, Ohio.
4. "Extreme Pressure Lubrication and Wear"
   A. Dorinson, V. E. Broman, Sinclair Research Labs., Harvey, Illinois.



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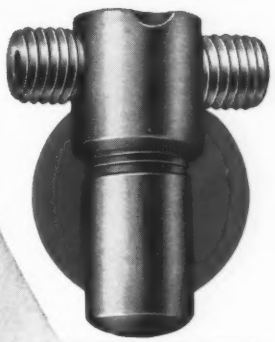

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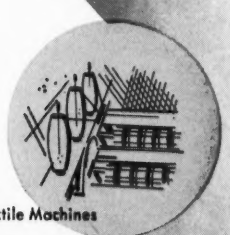

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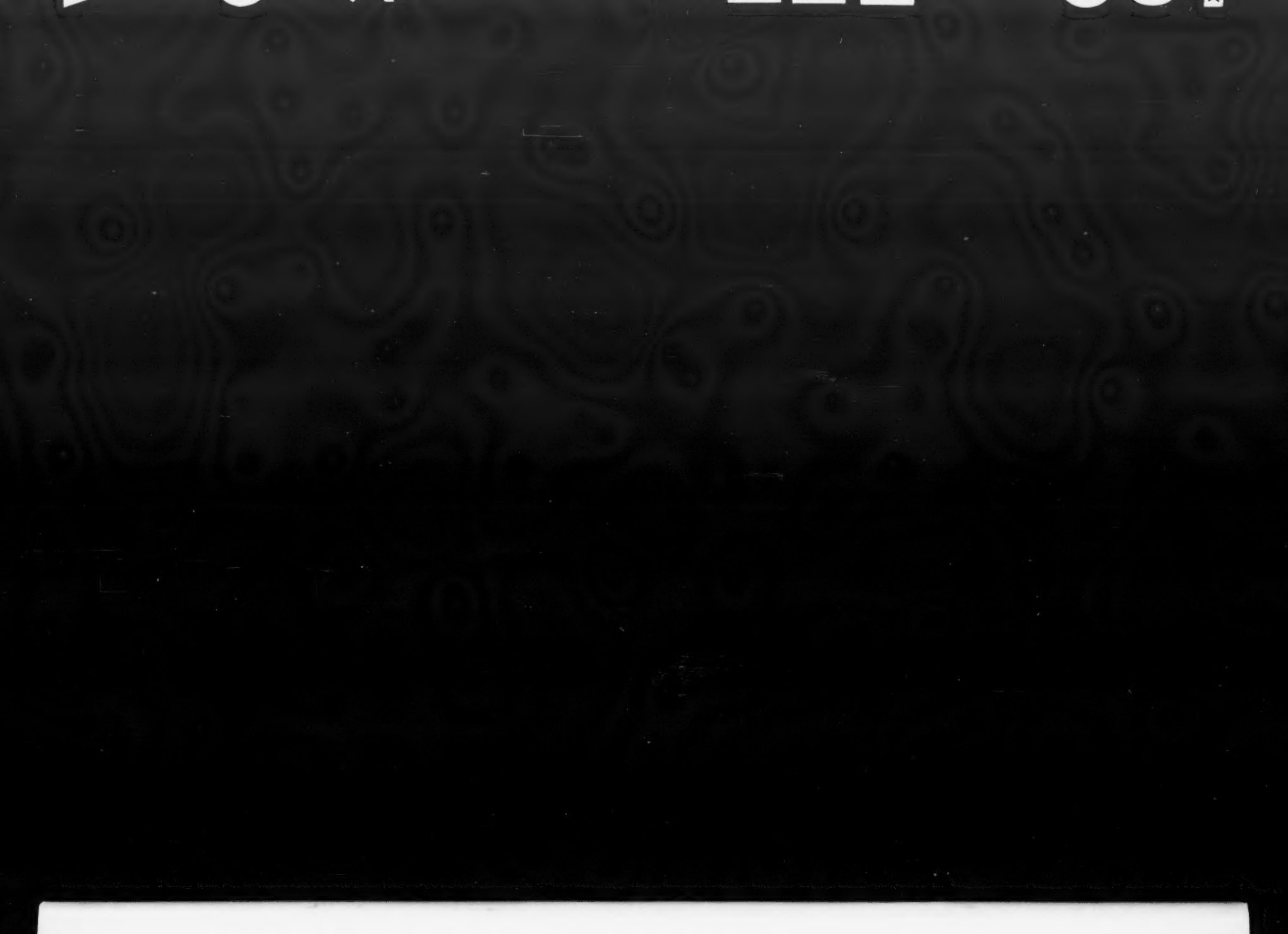
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